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CHEMISTRY



EXAM QUESTION PACK

11 GROUP 17

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Chapter 11

Group 17

11.1 Physical properties of the Group 17 elements

610. 9701_s21_qp_13 Q: 15

When descending Group 17 from chlorine to iodine, which statement is correct?

A The hydrides become less thermally stable as they become weaker reducing agents.

B The hydrides become more thermally stable as the reactivity of the elements decreases.

C The volatility of the elements decreases as the van der Waals' forces increase.

D The volatility of the elements increases as the size of the molecules increases.

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611. 9701_s20_qp_12 Q: 7

When aqueous bromine is shaken with cyclohexane and allowed to stand, two layers form. The top cyclohexane layer is coloured and the bottom aqueous layer is almost colourless.

What is the most likely explanation for this observation?

A Bromine is reduced to bromide ions in the bottom layer.

B Bromine molecules are non-polar.

C Bromine reacts with water but cannot react with cyclohexane.

D The product of the reaction between bromine and cyclohexane is coloured.

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612. 9701_s20_qp_12 Q: 14

Which statement explains why iodine is less volatile than chlorine?

A Chlorine is more electronegative than iodine and so has more repulsion between its molecules.

B The greater number of electrons in iodine leads to larger temporary dipole-induced dipole forces.

C The I–I bond energy is smaller than the Cl–Cl bond energy.

D The iodine molecules have stronger permanent dipole-permanent dipole forces.

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613. 9701_s20_qp_13 Q: 13

Which property explains the trend in volatility of the elements going down Group 17?

A decreasing covalent bond strength

B decreasing van der Waals' forces

C increasing covalent bond strength

D increasing van der Waals' forces

---

614. 9701_m19_qp_12 Q: 18

Under standard conditions, which statement is correct?

A Cl_2(aq) can oxidise Br^-(aq).

B Cl_2(aq) can reduce Br^-(aq).

C Cl^-(aq) can oxidise Br_2(aq).

D Cl^-(aq) can reduce Br_2(aq).

---

615. 9701_w19_qp_11 Q: 16

Chlorine and bromine have different volatilities.

Which row identifies the more volatile of the two elements, and gives the correct explanation?

	identity of the more volatile element	explanation for the difference in volatility
A	bromine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
B	bromine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine
C	chlorine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
D	chlorine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine

---

616. 9701_s18_qp_12 Q: 14

In this question, X represents an atom of chlorine, bromine or iodine.

Which explanation for the variation in volatility down Group 17 is correct?

A Instantaneous dipole-induced dipole forces between molecules become stronger.

B Permanent dipole-permanent dipole forces between molecules become stronger.

C The bond energy of the X_2 molecules decreases.

D The first ionisation energy $X(g) \rightarrow X^+(g) + e^-$ decreases.

---

617. 9701_w18_qp_11 Q: 16

Which row correctly describes the properties of the halogens as Group 17 is descended from chlorine to iodine?

	volatility	strength as oxidising agent
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

---

618. 9701_s17_qp_11 Q: 19

Redox reactions are common in the chemistry of Group 17.

Which statement is correct?

A Br^- ions will reduce Cl_2 but not I_2.

B Cl_2 will oxidise Br^- ions but not I^- ions.

C F_2 is the weakest oxidising agent out of F_2, Cl_2, Br_2 and I_2.

D I^- ions are the weakest reducing agent out of F^-, Cl^-, Br^- and I^-.

---

619. 9701_w17_qp_11 Q: 19

The strengths of the covalent bonds within halogen molecules, and the van der Waals' forces between halogen molecules, vary going down Group 17 from chlorine to bromine to iodine.

Which row shows these correctly?

	strength of covalent bonds	strength of van der Waals' forces
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

---

620. 9701_s16_qp_12 Q: 19

Fluorine and iodine are Group 17 elements. Their melting points are different due to differing strengths of van der Waals' forces between molecules.

Which row is correct?

	melting point	strength of van der Waals' forces between molecules
A	$F_2 > I_2$	$F_2 > I_2$
B	$F_2 > I_2$	$F_2 < I_2$
C	$F_2 < I_2$	$F_2 < I_2$
D	$F_2 < I_2$	$F_2 > I_2$

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621. 9701_w15_qp_11 Q: 17

Which statement about bromine is correct?

A Bromine is insoluble in non-polar solvents.

B Bromine vapour is more dense than air.

C Bromine will not vaporise significantly under normal conditions.

D Gaseous bromine is purple.

---

622. 9701_w15_qp_12 Q: 17

A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. Some observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

A Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.

B Concentrated phosphoric acid is a stronger oxidising agent than iodine.

C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.

D Concentrated sulfuric acid is a stronger oxidising agent than iodine.

11.2 The chemical properties of the halogen elements and the hydrogen halides

623. 9701_m22_qp_12 Q: 6

The boiling points of some hydrogen halides are shown.

hydrogen halide	boiling point / K
H–Cl	188
H–Br	206
H–I	238

What is the explanation for the trend in boiling point for the hydrogen halides from HCl to HI?

A The bond energies of the hydrogen halides increase from HCl to HI.

B There is an increase in the strength of the intermolecular forces of attraction from HCl to HI.

C The intermolecular hydrogen bonds become stronger from HCl to HI.

D There is an increase in the bond polarity from HCl to HI.

---

624. 9701_s20_qp_12 Q: 18

A test-tube of HBr(g) and a separate test-tube of HI(g) are heated to the same temperature.

Which combination of observations is possible?

	test-tube of HBr(g)	test-tube of HI(g)
A	a brown vapour appears	no change
B	a purple vapour appears	no change
C	no change	a brown vapour appears
D	no change	a purple vapour appears

---

625. 9701_w19_qp_12 Q: 16

The properties of chlorine, bromine and their compounds are compared.

Which property is **smaller** for chlorine than for bromine?

A bond strength of the hydrogen-halide bond

B first ionisation energy

C solubility of the silver halide in NH_3(aq)

D strength of the van der Waals' forces between molecules of the element

---

626. 9701_s17_qp_13 Q: 17

A test-tube of HBr(g) and a separate test-tube of HI(g) are heated to the same temperature.

Which combination of observations is possible?

	test-tube of HBr(g)	test-tube of HI(g)
A	a brown vapour appears	no change
B	a purple vapour appears	no change
C	no change	a brown vapour appears
D	no change	a purple vapour appears

---

627. 9701_m16_qp_12 Q: 16

Hydrogen chloride gas and hydrogen iodide gas have different thermal stabilities. The difference is due to a difference in the energies of some of the covalent bonds that are involved in the decomposition.

Which row identifies the more stable of the two compounds, and gives the correct explanation?

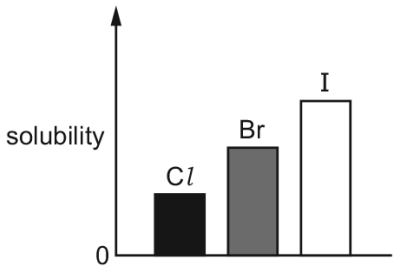
	identity of the more thermally stable compound	explanation for the difference in stability
A	hydrogen chloride	the C*l*–C*l* bond is stronger than the I–I bond
B	hydrogen chloride	the H–C*l* bond is stronger than the H–I bond
C	hydrogen iodide	the C*l*–C*l* bond is stronger than the I–I bond
D	hydrogen iodide	the H–C*l* bond is stronger than the H–I bond

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628. 9701_s16_qp_13 Q: 17

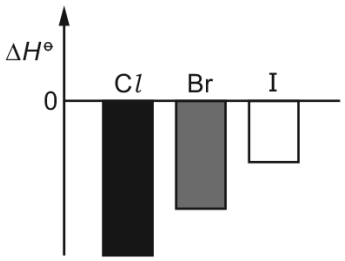
Two students, P and Q, were asked to draw bar charts to represent how some properties of the halogens and their compounds differ in magnitude. Their diagrams are shown. The bar charts show trends only and not actual values.

student P



solubility of AgX(s) in NH_3(aq)

student Q



$\Delta H^{\ominus}$ for $H_2(g) + X_2(g) \rightarrow 2HX(g)$

Which of the students have drawn bar charts which show the trends correctly?

A both P and Q

B P only

C Q only

D neither P nor Q

---

629. 9701_s16_qp_13 Q: 18

In a series of nine experiments to test the reactivity of the halogens, an aqueous solution of each halogen was added to an equal volume of an aqueous solution containing halide ions as shown in the table below.

solution	sodium chloride (aq)	sodium bromide (aq)	sodium iodide (aq)
chlorine (aq)	experiment 1	experiment 2	experiment 3
bromine (aq)	experiment 4	experiment 5	experiment 6
iodine (aq)	experiment 7	experiment 8	experiment 9

The nine resulting mixtures were then shaken with hexane. The nine tubes were corked and left to stand so that the aqueous and organic solvents could separate into layers.

How many test-tubes contained a purple upper layer?

A 1 **B** 2 **C** 3 **D** 5

---

630. 9701_w16_qp_11 Q: 19

X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2, Y_2 and Z_2 were separately added to separate aqueous solutions containing X^-, Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row of the following table contains the ions X^-, Y^- and Z^- in order of their **decreasing** strength as reducing agents?

	strongest ⟶		weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

11.3 Some reactions of the halide ions

631. 9701_m22_qp_12 Q: 11

Hydrogen peroxide, H_2O_2, decomposes to form water and oxygen.

The reaction is catalysed by bromide ions.

step 1 $2Br^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow 2H_2O(l) + Br_2(aq)$

step 2 $H_2O_2(aq) + Br_2(aq) \rightarrow 2Br^-(aq) + 2H^+(aq) + O_2(g)$

Which row is correct?

	type of catalyst	in step 1
A	heterogeneous	bromide ions are oxidised
B	heterogeneous	bromide ions are reduced
C	homogeneous	bromide ions are oxidised
D	homogeneous	bromide ions are reduced

632. 9701_m22_qp_12 Q: 22

Which statement relating to the elements in Group 17 and their compounds is correct?

A Bromine will reduce KI to form iodine.

B Iodide ions react to form a white precipitate when added to silver nitrate solution.

C Bromide ions react to form a white precipitate when added to silver nitrate solution.

D Chlorine reacts with hydrogen to form a colourless gas.

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633. 9701_m21_qp_12 Q: 17

When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.

Which statement is correct?

A Hydrogen sulfide is the product of a reduction reaction.

B Iodide ions are stronger oxidising agents than sulfate ions.

C Sulfur atoms from the sulfuric acid are both oxidised and reduced.

D Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

---

634. 9701_s21_qp_11 Q: 16

A $5\,cm^3$ sample of $0.05\,mol\,dm^{-3}$ sodium chloride is mixed with a $5\,cm^3$ sample of $0.05\,mol\,dm^{-3}$ potassium iodide. $10\,cm^3$ of acidified $0.05\,mol\,dm^{-3}$ silver nitrate is then added, followed by concentrated ammonia solution.

What is seen after the addition of an excess of concentrated ammonia solution?

A a cream precipitate

B a white precipitate

C a yellow precipitate

D no precipitate

---

635. 9701_s21_qp_12 Q: 16

Which row gives mixtures that **both** result in the oxidation of a halide ion?

	mixture 1	mixture 2
A	$AgNO_3$(aq) and NaCl(aq)	concentrated H_2SO_4(aq) and HI(aq)
B	Br_2(aq) and NaCl(aq)	concentrated H_2SO_4(aq) and HCl(aq)
C	Cl_2(aq) and NaBr(aq)	$CH_3CHBrCH_3$(l) + NaOH (ethanolic)
D	Br_2(aq) and NaI(aq)	concentrated H_2SO_4(aq) and NaBr(s)

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636. 9701_s21_qp_13 Q: 16

A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water.

Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was then added, this precipitate partly dissolved leaving a darker yellow precipitate.

What could the powder be?

A sodium bromide only

B sodium iodide only

C a mixture of sodium chloride and sodium bromide

D a mixture of sodium chloride and sodium iodide

---

637. 9701_w21_qp_11 Q: 16

In a series of nine experiments, to test the reactivity of the halogens, an aqueous solution of each halogen is added to an equal volume of an aqueous solution containing halide ions, as shown in the table.

halogen solution	halide solution		
	sodium chloride (aq)	sodium bromide (aq)	sodium iodide (aq)
chlorine (aq)	experiment 1	experiment 2	experiment 3
bromine (aq)	experiment 4	experiment 5	experiment 6
iodine (aq)	experiment 7	experiment 8	experiment 9

The nine resulting mixtures are then shaken separately with an equal volume of hexane. The nine tubes are left to stand so that the aqueous and organic solvents separate into layers.

How many test-tubes contain a purple upper hexane layer?

A 1 **B** 2 **C** 3 **D** 5

---

638. 9701_w21_qp_12 Q: 15

Redox reactions are common in the chemistry of Group 17 elements.

Which statement is correct?

A Br^- ions will reduce Cl_2 but not I_2.

B Cl_2 will oxidise Br^- ions but not I^- ions.

C F_2 is the weakest oxidising agent out of F_2, Cl_2, Br_2 and I_2.

D I^- ions are the weakest reducing agent out of F^-, Cl^-, Br^- and I^-.

---

639. 9701_w21_qp_12 Q: 16

Silver chloride and silver iodide form equilibria when added to water.

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq) \qquad K_c = K_1$$

$$AgI(s) \rightleftharpoons Ag^+(aq) + I^-(aq) \qquad K_c = K_2$$

Each equilibrium position lies well to the **left**.

Silver iodide will not dissolve in aqueous ammonia. Silver chloride will dissolve in aqueous ammonia. Another equilibrium is formed.

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq) \qquad K_c = K_3$$

The position of this equilibrium lies to the **right**.

What is the order of magnitude for these three equilibrium constants?

	smallest ⟶		largest
A	K_3	K_2	K_1
B	K_3	K_1	K_2
C	K_2	K_1	K_3
D	K_1	K_2	K_3

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640. 9701_w21_qp_12 Q: 17

X is the ion of a metal which burns with a red flame.

Y is an ion that reacts with concentrated H_2SO_4 to produce H_2S.

What could be the formula of a compound containing X and Y?

A $BaBr_2$ **B** BaI_2 **C** $SrBr_2$ **D** SrI_2

---

641. 9701_w21_qp_13 Q: 18

Which row is correct?

	shape		bonds present	
	ammonia molecule	ammonium ion	ammonia molecule	ammonium ion
A	pyramidal	regular tetrahedral	σ	σ
B	pyramidal	regular tetrahedral	σ	π
C	regular tetrahedral	pyramidal	σ	σ
D	regular tetrahedral	pyramidal	π	σ

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642. 9701_m20_qp_12 Q: 18

How does concentrated sulfuric acid behave when it reacts with sodium chloride?

A as an acid only

B as an acid and oxidising agent

C as an oxidising agent only

D as a reducing agent only

---

643. 9701_s20_qp_11 Q: 12

A white powder is a mixture of sodium chloride and sodium iodide. It is dissolved in water in a test-tube. An excess of aqueous silver nitrate is added to the test-tube. A precipitate, X, is observed.

An excess of concentrated ammonia is then added to the test-tube containing X. After the test-tube has been shaken, a precipitate, Y, is observed.

Which statement about X or Y is correct?

A X is a pure white colour.

B X is pure silver iodide.

C Y is pure silver chloride.

D Y is yellow.

---

644. 9701_s20_qp_11 Q: 18

Astatine, At, is below iodine in Group 17 of the Periodic Table.

Which statement is most likely to be correct?

A AgAt(s) reacts with an excess of dilute aqueous ammonia to form a solution of a soluble complex.

B Astatine and KCl(aq) react to form KAt(aq) and chlorine.

C KAt(aq) and dilute sulfuric acid react to form HAt(g).

D NaAt(s) and concentrated sulfuric acid react to form astatine.

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645. 9701_s20_qp_13 Q: 17

The addition of aqueous silver nitrate to aqueous barium chloride produces a white precipitate which dissolves in an excess of dilute aqueous ammonia to form a colourless solution.

The addition of an excess of dilute nitric acid to the colourless solution produces a white precipitate, Z.

What is Z?

A AgCl **B** BaCl_2 **C** $Ba(NO_3)_2$ **D** NH_4NO_3

---

646. 9701_w20_qp_11 Q: 16

With which compound does concentrated sulfuric acid react **both** as a strong acid **and** as an oxidising agent?

A magnesium carbonate

B potassium chloride

C sodium bromide

D sulfur trioxide

---

647. 9701_m19_qp_12 Q: 17

The table shows some reactions of a white compound, G.

test	observation
silver nitrate is added to a solution of G followed by aqueous ammonia	a precipitate is formed which does not dissolve when the ammonia is added
solid G is warmed with concentrated sulfuric acid	a mixture of gases is formed including hydrogen sulfide

What could be the identity of G?

A caesium chloride

B lithium bromide

C potassium sulfate

D sodium iodide

---

648. 9701_s19_qp_11 Q: 16

Concentrated sulfuric acid is added to separate solid samples of sodium chloride, sodium bromide and sodium iodide.

With which samples does sulfuric acid act as an oxidising agent?

A sodium chloride only

B sodium chloride and sodium bromide

C sodium bromide and sodium iodide

D sodium iodide only

---

649. 9701_s19_qp_13 Q: 16

The solids sodium chloride and sodium iodide both react with concentrated sulfuric acid at room temperature.

With NaCl, the products are $NaHSO_4$ and HCl.
With NaI, the products are $NaHSO_4$, HI, I_2, SO_2, H_2O, S and H_2S.

What is the explanation for this difference in products?

A Chloride ions will displace iodine from solution.

B Hydrogen chloride is more volatile than hydrogen iodide.

C Iodide ions are better reducing agents than chloride ions.

D Sulfuric acid is able to act as a dehydrating agent with NaI.

---

650. 9701_s19_qp_13 Q: 17

An aqueous solution of a calcium compound is treated with a mixture of dilute aqueous nitric acid and aqueous silver nitrate. The resulting white precipitate dissolves when dilute aqueous ammonia is added.

What is the relative molecular mass, M_r, of the calcium compound?

A 54.0 **B** 75.6 **C** 111.1 **D** 199.9

---

651. 9701_w19_qp_11 Q: 17

Sodium azide, NaN_3, is dissolved in water. Acidified silver nitrate is added to the solution and a white precipitate forms. Aqueous ammonia is then added to the white precipitate.

The azide ion, N_3^-, has similar chemical properties to the Cl^- ion.

Which row of the table can be predicted from this information?

	formula of white precipitate	observation on adding aqueous ammonia
A	AgN_3	colourless solution formed
B	AgN_3	precipitate remains
C	Ag_3N	colourless solution formed
D	Ag_3N	precipitate remains

---

652. 9701_w19_qp_12 Q: 17

Solid sodium iodide reacts with concentrated sulfuric acid to form more than one product that contains sulfur.

What is the lowest oxidation number of sulfur in these products?

A –2 **B** 0 **C** +4 **D** +6

---

653. 9701_s18_qp_11 Q: 16

Aqueous silver nitrate is added to a solution of potassium iodide.

Aqueous ammonia is then added.

What would be observed?

A a cream precipitate that dissolves on addition of aqueous ammonia

B a cream precipitate that does not dissolve on addition of aqueous ammonia

C a yellow precipitate that dissolves on addition of aqueous ammonia

D a yellow precipitate that does not dissolve on addition of aqueous ammonia

---

654. 9701_s18_qp_12 Q: 17

When concentrated sulfuric acid is added to solid sodium bromide, bromine gas is produced, along with a number of other products. However when concentrated sulfuric acid is added to solid sodium chloride **only** hydrogen chloride and sodium hydrogensulfate are produced.

What is the reason for this difference?

A Bromine is less volatile than chlorine.

B Hydrochloric acid is a weak acid.

C Sulfuric acid is not an oxidising agent.

D The bromide ion is a stronger reducing agent than the chloride ion.

---

655. 9701_s18_qp_13 Q: 16

When concentrated sulfuric acid is added to solid sodium chloride, HCl is formed but not Cl_2.

When concentrated sulfuric acid is added to solid sodium iodide, I_2 is formed.

Which statement explains these observations?

A Sulfuric acid is an oxidising agent and chloride ions are more easily oxidised.

B Sulfuric acid is an oxidising agent and iodide ions are more easily oxidised.

C Sulfuric acid is a reducing agent and chloride ions are more easily reduced.

D Sulfuric acid is a reducing agent and iodide ions are more easily reduced.

---

656. 9701_w18_qp_12 Q: 16

Which statement about the halogens is correct?

A Iodine cannot behave as an oxidising agent.

B The volatility of the elements increases from chlorine to iodine because of the increase in molecular size down the group.

C When an equimolar mixture of chlorine and hydrogen is exploded, only one product is formed.

D When concentrated sulfuric acid is added to solid sodium bromide, hydrogen sulfide is one of the products.

---

657. 9701_s17_qp_11 Q: 17

When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.

Which statement is correct?

A Hydrogen sulfide is the product of a reduction reaction.

B Iodide ions are stronger oxidising agents than sulfate ions.

C Sulfur atoms from the sulfuric acid are both oxidised and reduced.

D Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

---

658. 9701_s17_qp_12 Q: 17

A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water.

Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was then added, this precipitate partly dissolved leaving a darker yellow precipitate.

What might the powder be?

A sodium bromide only

B sodium iodide only

C a mixture of sodium chloride and sodium bromide

D a mixture of sodium chloride and sodium iodide

---

659. 9701_w17_qp_11 Q: 18

Compound Q is a white crystalline solid which dissolves easily in water. When concentrated sulfuric acid is added to a dry sample of Q steamy white fumes are formed which, when passed through aqueous silver nitrate solution, form a white precipitate. This precipitate is soluble in dilute ammonia solution.

What could be the identity of compound Q?

A AgCl **B** NaBr **C** NaCl **D** $PbBr_2$

---

660. 9701_w17_qp_12 Q: 17

Sodium bromide reacts with concentrated sulfuric acid.

Which observation will be made?

A A coloured vapour is produced.

B A purple solid is formed.

C A strong smell of H_2S is detected.

D Yellow sulfur is formed.

---

661. 9701_s16_qp_11 Q: 15

The solids sodium chloride and sodium iodide both react with concentrated sulfuric acid at room temperature.

With NaCl, the products are $NaHSO_4$ and HCl.
With NaI, the products are $NaHSO_4$, HI, I_2, SO_2, H_2O, S and H_2S.

What is the best explanation for this difference in products?

A Chloride ions will displace iodine from solution.

B Hydrogen chloride is more volatile than hydrogen iodide.

C Iodide ions are better reducing agents than chloride ions.

D Sulfuric acid is able to act as a dehydrating agent with NaI.

---

662. 9701_w16_qp_11 Q: 14

The properties of chlorine, bromine and their compounds are compared.

Which property is **smaller** for chlorine than for bromine?

A bond strength of the hydrogen-halide bond

B first ionisation energy

C solubility of the silver halide in NH_3(aq)

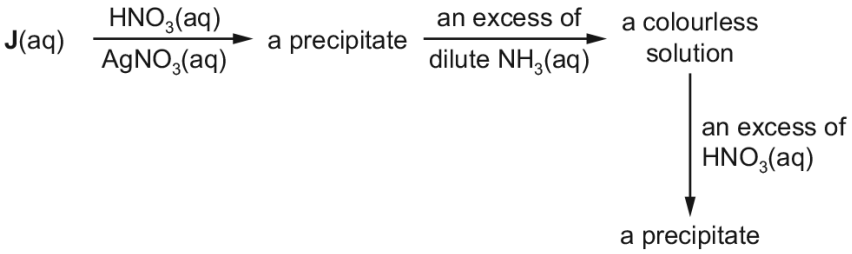
D strength of the van der Waals' forces between molecules of the element

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663. 9701_w16_qp_12 Q: 16

J is a salt of one of the halogens chlorine, bromine, iodine or astatine.

The reaction scheme shows a series of reactions using a solution of **J** as the starting reagent.



What could **J** be?

A sodium chloride

B sodium bromide

C potassium iodide

D potassium astatide

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664. 9701_s15_qp_11 Q: 17

Astatine, At, is below iodine in Group VII of the Periodic Table.

Which statement is most likely to be correct?

A AgAt(s) reacts with excess dilute aqueous ammonia to form a solution of a soluble complex.

B Astatine and KCl(aq) react to form KAt(aq) and chlorine.

C KAt(aq) and dilute sulfuric acid react to form white fumes of HAt(g).

D NaAt(s) and concentrated sulfuric acid react to form astatine.

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665. 9701_s15_qp_13 Q: 19

Two separate tests were carried out on an aqueous solution of a salt which contains only two ions.

In each test, the resulting mixtures were filtered and the filtrate solution was collected.

	reagent	result	filtrate collected
test 1	aqueous silver nitrate acidified with dilute nitric acid	yellow precipitate forms	solution P
test 2	dilute sulfuric acid	white precipitate forms	solution Q

Which ions are present in the filtrates?

	solution P	solution Q
A	$Ba^{2+}(aq)$	$Cl^{-}(aq)$
B	$Ba^{2+}(aq)$	$I^{-}(aq)$
C	$Mg^{2+}(aq)$	$Cl^{-}(aq)$
D	$Mg^{2+}(aq)$	$I^{-}(aq)$

---

666. 9701_w15_qp_11 Q: 18

The addition of aqueous silver nitrate to aqueous barium chloride produces a white precipitate which dissolves in excess dilute aqueous ammonia to form a colourless solution.

The addition of excess dilute nitric acid to the colourless solution produces a white precipitate, **Z**.

What is **Z**?

A $AgCl$ **B** $BaCl_2$ **C** $Ba(NO_3)_2$ **D** NH_4NO_3

---

667. 9701_w15_qp_12 Q: 18

A white powder is a mixture of sodium chloride and sodium iodide. It is dissolved in water in a test-tube. Excess aqueous silver nitrate is added to the test-tube. A precipitate, X, is observed.

Excess concentrated ammonia is then added to the test-tube containing X. After the test-tube has been shaken, a precipitate, Y, is observed.

Which statement about X or Y is correct?

A X is a pure white colour.

B X is pure silver iodide.

C Y is pure silver chloride.

D Y is yellow.

11.4 The reactions of chlorine

668. 9701_m22_qp_12 Q: 23

An excess of chlorine was bubbled into 100 cm^3 of hot 6.0 mol dm^{-3} sodium hydroxide.

How many moles of sodium chloride would be produced in the reaction?

A 0.30 **B** 0.50 **C** 0.60 **D** 0.72

---

669. 9701_m21_qp_12 Q: 16

Chlorine gas is reacted with aqueous sodium hydroxide. The oxidation number of chlorine changes from 0 to –1 and also from 0 to +1.

Under which conditions does this reaction occur and what is the colour of the solid silver salt with chlorine in the oxidation state –1?

	reaction conditions	colour of silver salt
A	cold, dilute alkali	white
B	cold, dilute alkali	yellow
C	hot, concentrated alkali	white
D	hot, concentrated alkali	yellow

---

670. 9701_s21_qp_12 Q: 17

Chlorine gas is widely used to treat contaminated water.

When chlorine is added to water, which chemical species present is responsible for killing bacteria?

A ClO_2^- **B** Cl^- **C** HCl **D** ClO^-

---

671. 9701_w21_qp_11 Q: 17

Z is a compound of sodium, chlorine and oxygen.

It contains 45.1% by mass of oxygen.

Z is prepared by reacting sodium hydroxide with chlorine.

Which row shows the conditions used for the reaction and the oxidation state of chlorine in Z?

	reaction conditions	oxidation state of Cl in Z
A	cold dilute NaOH	+1
B	cold dilute NaOH	+5
C	hot concentrated NaOH	+1
D	hot concentrated NaOH	+5

672. 9701_m20_qp_12 Q: 14

Hot aqueous sodium hydroxide reacts with chlorine.

$$6NaOH(aq) + 3Cl_2(g) \rightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$$

Which statement is correct?

A The oxidation numbers of chlorine and hydrogen both change in the reaction.

B The oxidation numbers of chlorine in the products are –1 and +1.

C If the aqueous sodium hydroxide is cold the reaction produces NaClO instead of NaClO$_3$.

D Sodium undergoes disproportionation in this reaction.

673. 9701_w20_qp_12 Q: 17

Which statement about Group 17 elements and their compounds is correct?

A Chlorine reacts with cold concentrated sodium hydroxide to form NaCl and NaClO$_3$.

B HCl is more thermally stable than HBr because chlorine is less electronegative than bromine.

C Iodide ions are oxidised to iodine by concentrated sulfuric acid.

D Silver iodide is soluble in dilute aqueous ammonia.

674. 9701_s19_qp_11 Q: 17

The reaction of bromine with warm NaOH(aq) produces products with the same oxidation numbers, in the same ratios, as the reaction of chlorine with hot NaOH(aq).

In one reaction between bromine and warm NaOH(aq), 30.2 g of a product containing sodium, bromine and oxygen is produced.

Which mass of NaOH has reacted?

A 8.00 g **B** 10.2 g **C** 20.3 g **D** 48.0 g

---

675. 9701_s19_qp_12 Q: 17

An excess of chlorine was bubbled into 100 cm^3 of hot 6.0 mol dm^{-3} sodium hydroxide.

How many moles of sodium chloride would be produced in the reaction?

A 0.3 **B** 0.5 **C** 0.6 **D** 1.2

---

676. 9701_m18_qp_12 Q: 24

Structural isomerism and stereoisomerism should be considered when answering this question.

The molecular formula of compound X is $C_5H_{12}O$.

Compound X:

- reacts with alkaline aqueous iodine
- can be dehydrated to form two alkenes only.

What could be the identity of compound X?

A $CH_3CH_2CH(CH_3)CH_2OH$

B $CH_3CH_2CH(OH)CH_2CH_3$

C $(CH_3)_2CHCH(OH)CH_3$

D $CH_3CH_2CH_2CH(OH)CH_3$

---

677. 9701_s18_qp_11 Q: 14

Chlorine reacts with **cold** aqueous sodium hydroxide to produce sodium chloride, water and compound X.

Chlorine reacts with **hot** aqueous sodium hydroxide to produce sodium chloride, water and compound Y.

What are the oxidation states of chlorine in compound X and compound Y?

	X	Y
A	–1	–5
B	–1	+5
C	+1	–5
D	+1	+5

---

678. 9701_w18_qp_11 Q: 17

Reaction 1: chlorine reacts with cold aqueous sodium hydroxide to form solution Z.

Reaction 2: solution Z is heated and forms ClO_3^-(aq) and Cl^-(aq).

Which equations represent reaction 1 and reaction 2?

A reaction 1 $2Cl_2 + 4OH^- \rightarrow ClO_2^- + 3Cl^- + 2H_2O$
reaction 2 $3ClO_2^- \rightarrow 2ClO_3^- + Cl^-$

B reaction 1 $2Cl_2 + 4OH^- \rightarrow ClO_2^- + 3Cl^- + 2H_2O$
reaction 2 $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

C reaction 1 $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$
reaction 2 $2ClO^- + 2OH^- \rightarrow ClO_3^- + Cl^- + H_2O$

D reaction 1 $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$
reaction 2 $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

---

679. 9701_w18_qp_12 Q: 17

Chlorine reacts with both hot and cold sodium hydroxide to form products containing chlorine.

Cold sodium hydroxide forms sodium chlorate(X) and hot sodium hydroxide forms sodium chlorate(Y). X and Y are oxidation numbers.

Which equation is correct?

A Y = X – 6 **B** Y = X – 4 **C** Y = X + 4 **D** Y = X + 6

---

680. 9701_m17_qp_12 Q: 16

Some uses of chlorine and bromine are given.

Which is a use of bromine?

A making bleaches for textiles and the paper industry

B making CFCs

C making flame retardants and fire extinguishers

D making the polymer PVC

---

681. 9701_m17_qp_12 Q: 17

In an experiment, 0.600 mol of chlorine gas, Cl_2, is reacted with an excess of hot aqueous sodium hydroxide. One of the products is $NaClO_3$.

Which mass of $NaClO_3$ is formed?

A 21.3 g **B** 44.7 g **C** 63.9 g **D** 128 g

---

682. 9701_s17_qp_11 Q: 18

A solution of sodium hydroxide reacts with 3 mol of chlorine under certain conditions. The reaction produces 5 mol of sodium chloride and 1 mol of **X**, the only other chlorine-containing product.

What is the formula of compound **X**?

A $NaClO$ **B** $NaClO_2$ **C** $NaClO_3$ **D** $NaClO_4$

---

683. 9701_s17_qp_12 Q: 16

Element X reacts with cold, dilute, aqueous sodium hydroxide to form two different chlorine-containing products, Y and Z.

What are the oxidation states of chlorine in Y and Z?

	Y	Z
A	0	+1
B	0	+5
C	–1	+1
D	–1	+5

---

684. 9701_s17_qp_13 Q: 16

Chlorine gas is added to cold, aqueous sodium hydroxide.

In a separate experiment, chlorine gas is added to hot, aqueous sodium hydroxide.

Which oxidation states of chlorine are found in the reactants and products of the two reactions that take place?

A 0, –1, +1 and +5

B 0, –1 and +1 only

C 0, –1 and +5 only

D 0, +1 and +5 only

---

685. 9701_w17_qp_11 Q: 17

71.0 g of chlorine, Cl_2, react with an excess of sodium hydroxide solution at a particular temperature. The reaction produces exactly 35.5 g of product **X**.

What is product **X**?

A H_2O **B** $NaCl$ **C** $NaClO$ **D** $NaClO_3$

---

686. 9701_w17_qp_12 Q: 16

In an experiment, 0.125 mol of chlorine gas, Cl_2, is reacted with an excess of cold, aqueous sodium hydroxide. One of the products is a compound of sodium, oxygen and chlorine.

Which mass of this product is formed?

A 9.31 g **B** 13.3 g **C** 18.6 g **D** 26.6 g

---

687. 9701_m16_qp_12 Q: 14

Chlorine gas is widely used to treat contaminated water.

Which species present in water when chlorine gas has been added is responsible for killing bacteria?

A ClO_2^- **B** Cl^- **C** HCl **D** OCl^-

---

688. 9701_s16_qp_12 Q: 18

An excess of chlorine gas, Cl_2, is passed through 60 cm^3 of cold aqueous 0.1 mol dm^{-3} sodium hydroxide. In a separate experiment an excess of chlorine gas is passed through 60 cm^3 of hot aqueous 0.1 mol dm^{-3} sodium hydroxide until no further reaction takes place.

How much **more** sodium chloride will be produced by the reaction with hot NaOH than with cold NaOH?

A 0.002 moles

B 0.003 moles

C 0.005 moles

D 0.006 moles

---

689. 9701_w16_qp_12 Q: 15

When chlorine reacts with hot aqueous sodium hydroxide, two chlorine-containing ions are formed. One of these is the chloride ion, Cl^-.

What is the other ion?

A ClO^- **B** ClO_2^- **C** ClO_3^- **D** ClO_4^-

---

690. 9701_s15_qp_11 Q: 16

Chlorine is widely used in water treatment plants.

Which reaction takes place when chlorine dissolves in water?

A $Cl_2 + H_2O \rightarrow HCl + HClO$

B $2Cl_2 + 2H_2O \rightarrow 3HCl + HClO_2$

C $3Cl_2 + 3H_2O \rightarrow 5HCl + HClO_3$

D $4Cl_2 + 4H_2O \rightarrow 7HCl + HClO_4$

Chapter 11

Group 17

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11.1 Physical properties of the Group 17 elements

62. 9701_m17_qp_22 Q: 2

Hydrogen halides are compounds formed when halogens (Group 17 elements) react with hydrogen. The bond polarity of the hydrogen halides decreases from HF to HI.

Some relevant data are shown in the table.

hydrogen halide	HF	HC*l*	HBr	HI
boiling point / °C	19	–85	–67	–35
H–X bond energy / kJ mol^{-1}	562	431	366	299

(a) (i) Explain the meaning of the term *bond polarity*.

.....

.....

..... [1]

(ii) Suggest why the boiling point of HF is **much** higher than the boiling points of the other hydrogen halides.

.....

.....

.....

.....

..... [2]

(iii) Describe and explain the relative thermal stabilities of the hydrogen halides.

.....

.....

.....

.....

.....

..... [3]

(b) The equation for the preparation of hydrogen chloride using concentrated sulfuric acid is shown.

$$H_2SO_4 + NaCl \rightarrow NaHSO_4 + HCl$$

(i) Use the Brønsted-Lowry theory of acids and bases to identify the base and its conjugate acid in this reaction. Explain your answer.

Brønsted-Lowry base (base-I) = ...

conjugate acid (acid-II) = ...

.....

.....

.....

[2]

(ii) Explain why the reaction of concentrated sulfuric acid and sodium iodide is **not** suitable for the preparation of hydrogen iodide.

.....

.....

.....

..... [2]

(c) Hydrogen chloride undergoes a reversible reaction with oxygen.

$$4HCl(g) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(g)$$

The reaction is carried out at 400 °C in the presence of a copper(II) chloride catalyst.

(i) Use the data in the table to calculate the overall enthalpy change of reaction.

compound	enthalpy change of formation / kJ mol^{-1}
$HCl(g)$	–92
$H_2O(g)$	–242

enthalpy change of reaction = ... kJ mol^{-1} [2]

(ii) State the **type** of catalyst used in this reaction. Explain how a catalyst is able to increase the rate of a chemical reaction.

.....

.....

.....

..... [2]

(iii) The reaction exists in dynamic equilibrium.

The reaction was repeated at 1000 °C and the same pressure.

State and explain the effect on the composition of the equilibrium mixture of the change in temperature.

.....

.....

.....

..... [2]

(iv) When 1.60 mol of HCl are mixed in a sealed container with 0.500 mol of O_2 at 400 °C, 0.600 mol of Cl_2 and 0.600 mol of H_2O are formed.

The total pressure inside the container is 1.50×10^5 Pa.

- Calculate the amounts, in mol, of HCl and O_2 in the equilibrium mixture.

HCl = ... mol

O_2 = ... mol

- Calculate the mole fraction of Cl_2 and hence the partial pressure of Cl_2 in the equilibrium mixture.

mole fraction of Cl_2 = ...

p_{Cl_2} = ... Pa

[3]

(v) In a separate experiment, an equilibrium reaction mixture was found to contain the four gases at the partial pressures shown in the table.

gas	HCl	O_2	Cl_2	H_2O
partial pressure / Pa	4.8×10^4	3.0×10^4	3.6×10^4	3.6×10^4

$$K_p = \frac{(p_{Cl_2})^2 \times (p_{H_2O})^2}{(p_{HCl})^4 \times p_{O_2}}$$

Use this information and the expression given for K_p to calculate a value for K_p. State the units of K_p.

K_p = ...

units = ...
[2]

(vi) The reaction is repeated without a catalyst.

State the effect of this on K_p.

..... [1]

[Total: 22]

63. 9701_w17_qp_22 Q: 3

The elements in Group 2 show trends in their properties that are typical of metals.
The elements in Group 17 show trends in their properties that are typical of non-metals.

(a) State and explain the trend in ionisation energy down Group 2.

.....

.....

..... [2]

(b) **(i)** State and explain the trend in melting point down Group 17.

.....

.....

..... [2]

(ii) The melting point decreases down Group 2.

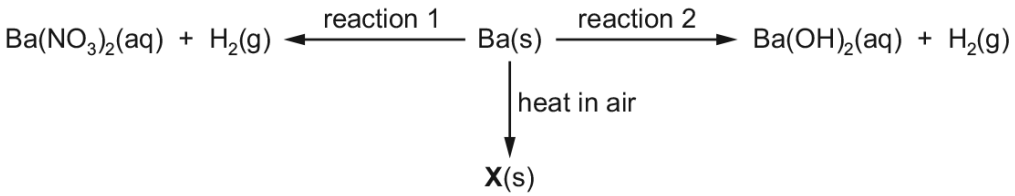
Explain this trend.

.....

.....

..... [2]

(c) Some reactions based on the Group 2 metal barium, Ba, are shown.



(i) State the reagent needed for each of reactions 1 and 2.

reaction 1 .....

reaction 2 .....

[2]

(ii) Name **X** and write an equation for its formation.

name .....

equation .....

[2]

(iii) The $Ba(NO_3)_2(aq)$, produced by reaction 1, is heated to dryness. The anhydrous solid is then heated strongly and decomposes. Barium oxide is produced, together with two other products.

Identify the **two** other products of this decomposition reaction and state what would be observed.

.....

..... [2]

(iv) State what would be observed when excess $MgSO_4(aq)$ is added to the $Ba(OH)_2(aq)$ produced in reaction 2. Explain your answer.

.....

.....

.....

..... [3]

[Total: 15]

11.2 The chemical properties of the elements and their hydrides

64. 9701_s19_qp_22 Q: 2

Group 17 elements are commonly referred to as the halogens.

(a) State and explain the trend in volatility of chlorine, bromine and iodine down the group.

.....

.....

.....

..... [3]

Hydrogen gas reacts with the different halogens under different conditions.

(b) (i) State the conditions required for chlorine to react with hydrogen at room temperature.

..... [1]

(ii) On heating, iodine reacts with hydrogen in a reversible reaction.

Give the equation for this reaction. Include state symbols.

..... [2]

(c) Hydrogen chloride reacts with water.

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

(i) In this reaction, one of the reactants behaves as a Brønsted-Lowry acid.

What is meant by the term *Brønsted-Lowry acid*?

.....

..... [1]

(ii) Identify the reactant behaving as an acid and its conjugate base.

acid .....

conjugate base .....
[1]

(iii) Name the type of bond formed between H^+ and H_2O to make H_3O^+.

..... [1]

(iv) For H_3O^+, predict its shape and the H–O–H bond angle.

shape .....

bond angle .....
[2]

[Total: 11]

65. 9701_s16_qp_22 Q: 2

The elements in Group 17, the halogens, and their compounds, show many similarities and trends in their properties. Some data are given for the elements fluorine to iodine.

element	bond energy / kJ mol^{-1}	standard enthalpy change of atomisation, $\Delta H_{at}^{\ominus}$ / kJ mol^{-1}	boiling point of element / K	boiling point of **hydrogen halide** / K
fluorine, F–F	158	79	85	293
chlorine, C*l*–C*l*	242	121	238	188
bromine, Br–Br	193	112	332	206
iodine, I–I	151	107	457	238

(a) (i) Explain the meaning of the term *standard enthalpy change of atomisation*.

.....

.....

..... [3]

(ii) For fluorine and chlorine, the enthalpy changes of atomisation are half the value of the bond energies.

For bromine and iodine, the enthalpy changes of atomisation are much more than half the value of the bond energies.

Suggest a reason for this difference.

.....

.....

..... [1]

(iii) The standard enthalpy of formation of iodine monochloride, IC*l*, is –24.0 kJ mol^{-1}.

Use this information and the bond energies of iodine and chlorine to calculate the I–C*l* bond energy.

I–C*l* bond energy = ... kJ mol^{-1} [2]

(b) (i) Explain the trend in the boiling points of the hydrogen halides, HC*l*, HBr and HI.

.....

.....

..... [2]

(ii) Suggest why the hydrogen halide HF does not follow the trend in boiling points shown by HC*l*, HBr and HI.

.....

.....

..... [2]

(c) In an experiment, two of the halogens are represented as $\mathbf{P}_2$ and $\mathbf{Q}_2$.

$\mathbf{P}_2$ combines with hydrogen on heating to form H**P**, which can be easily broken down into its elements. A solution of H**P** in water reacts with aqueous silver ions to form a yellow precipitate that is insoluble in dilute aqueous ammonia.

$\mathbf{Q}_2$ combines explosively with hydrogen in sunlight to form H**Q**, which is stable to heat. A solution of H**Q** in water reacts with aqueous silver ions to form a white precipitate that is soluble in dilute aqueous ammonia.

(i) Identify the halogens $\mathbf{P}_2$ and $\mathbf{Q}_2$.

$\mathbf{P}_2$ = ... $\mathbf{Q}_2$ = ...
[1]

(ii) H**P** readily decomposes into its elements when heated but H**Q** is stable to heat.
Explain this with reference to bond energies.

.....

.....

..... [2]

(iii) Write an equation for the thermal decomposition of H**P**.

..... [1]

(iv) Write ionic equations, including state symbols, for

1. the formation of the white precipitate on addition of aqueous silver ions to aqueous H**Q**,

   .....

2. the subsequent dissolving of this precipitate in dilute aqueous ammonia.

   .....

[2]

(d) Chlorine reacts directly with many elements to form chlorides. Three such compounds are $MgCl_2$, $AlCl_3$ and $SiCl_4$.

(i) State and explain the pattern shown by the formulae of these three chlorides.

.....

.....

..... [2]

(ii) Write equations to show the behaviour of each of these chlorides when added to water.

$MgCl_2$ .....

$AlCl_3$ .....

$SiCl_4$ .....

[3]

[Total: 21]

11.3 Some reactions of the halide ions

66. 9701_s21_qp_21 Q: 3

Sodium halide salts react with concentrated sulfuric acid at room temperature.

(a) (i) Write an equation to represent the reaction of NaCl(s) with concentrated sulfuric acid.

..... [1]

(ii) Name this type of reaction.

..... [1]

(b) NaI(s) reacts with concentrated sulfuric acid, at room temperature, to form steamy fumes.

(i) Identify the chemical responsible for the steamy fumes.

..... [1]

(ii) The reaction of NaI(s) with concentrated sulfuric acid continues, forming several other products, including a dark grey solid.

Identify the chemical responsible for the dark grey solid and **one** other product of this further reaction.

dark grey solid .....

other product .....

[2]

(c) Explain the differences in observations, at room temperature, when NaI(s) reacts with concentrated sulfuric acid compared to those for NaCl(s).

.....

.....

..... [2]

(d) Complete the equation for the reaction of Br^- with excess concentrated H_2SO_4 at room temperature.

.....Br^- + ...H^+ + ...H_2SO_4 → .....

[1]

[Total: 8]

67. 9701_s21_qp_22 Q: 1

A Group 2 metal combines with bromine to form a crystalline solid, **M**Br_2.

Excess aqueous $AgNO_3$ is added to a solution of **M**Br_2 and a precipitate forms. The mixture is filtered. The precipitate is dried and the mass of the precipitate is recorded.

(a) State the formula and colour of the precipitate.

..... [2]

(b) Complete the equation to represent the reaction between **M**Br_2 and $AgNO_3$.

.....**M**Br_2 + ...$AgNO_3$ $\rightarrow$ ..... [1]

(c) A 0.250 g sample of pure **M**Br_2 contains 8.415×10^{-4} mol **M**Br_2.

Calculate the relative formula mass, M_r, of **M**Br_2. Use this to identify **M**.

Show your working.

M_r = ...

M = ...
[3]

(d) A sample of **M**Br_2 is dissolved in water. Chlorine gas is then bubbled into the solution.

(i) Describe the observations for this reaction.

.....

..... [1]

(ii) Name the type of reaction that occurs when **M**Br_2 reacts with chlorine gas.

..... [1]

(e) Compound **Y** is a pure **insoluble** solid which contains halide ions.

A single reagent is added directly to compound **Y** to determine the halide ion present.

Identify the reagent added. State the observation which would confirm that **Y** contains bromide ions.

reagent .....

observation .....

[2]

(f) Separate 1.0 g samples of three different magnesium salts are tested in order to identify the anion present in each sample.

(i) Explain how the action of heat is used to identify which sample is:

- $MgCO_3$
- $Mg(NO_3)_2$
- MgO.

.....

.....

.....

.....

..... [3]

(ii) Complete the electron configuration of the magnesium cation present in these salts.

$1s^2$ ..... [1]

(g) A sample of $MgCO_3(s)$ is distinguished from a sample of $Mg(OH)_2(s)$ by adding a small amount of each solid to $HCl(aq)$.

State **one** similarity and **one** difference in these two reactions.

similarity .....

.....

difference .....

.....

[2]

[Total: 16]

68. 9701_m20_qp_22 Q: 2

The Group 17 elements, chlorine, bromine and iodine, are non-metals that show trends in their physical and chemical properties.

(a) Describe the trend in the colour of the Group 17 elements down the group.

.....

..... [1]

(b) The Group 17 elements can oxidise many metals to form halides.

(i) Describe the relative reactivity of the elements in Group 17 as oxidising agents.

.....

..... [1]

(ii) Chlorine reacts with hot tin metal to form tin(IV) chloride, $SnCl_4$.

$SnCl_4$ is a colourless liquid at room temperature that reacts vigorously with water to form an acidic solution.

Suggest the type of structure and bonding shown by $SnCl_4$. Explain your answer.

.....

.....

.....

.....

..... [2]

(c) The Group 17 elements form soluble halides with sodium.

(i) Describe what is seen when dilute $AgNO_3(aq)$ is added to NaBr(aq) followed by aqueous ammonia.

.....

.....

..... [2]

(ii) NaC*l* reacts with concentrated H_2SO_4 to form HC*l* and $NaHSO_4$.

Explain the difference between the reactions of concentrated H_2SO_4 with NaC*l* and with NaI. Your answer should refer to the role of the sulfuric acid in each reaction.

.....

.....

.....

.....

.....

..... [3]

(d) The hydrogen halides are useful reagents in organic and inorganic reactions.

(i) Describe and explain the trend in the boiling points of the hydrogen halides, HC*l*, HBr and HI.

.....

.....

.....

..... [2]

(ii) Describe and explain the trend in the thermal stabilities of the hydrogen halides, HC*l*, HBr and HI.

.....

.....

.....

..... [2]

(e) Lucas's reagent is a mixture of HCl and ZnCl_2. Primary, secondary and tertiary alcohols can be distinguished by their reaction with Lucas's reagent.

Alcohols react with the HCl in Lucas's reagent to form halogenoalkanes.

ZnCl_2 acts as a homogeneous catalyst for these reactions.

(i) Explain the meaning of the term *homogeneous*.

.....

..... [1]

(ii) Pentan-3-ol, $C_2H_5CH(OH)C_2H_5$, reacts slowly with HCl to form a secondary halogenoalkane.

Complete the equation for this reaction using structural formulae.

$C_2H_5CH(OH)C_2H_5$ + ... [1]

(iii) The fastest reaction shown by Lucas's reagent is with a tertiary alcohol.

Draw the structure of the tertiary alcohol that is an isomer of pentan-3-ol.

[1]

(iv) Tertiary alcohols tend to react with Lucas's reagent using the same mechanism as in their reaction with HCl.

Suggest the type of reaction shown by tertiary alcohols with Lucas's reagent.

..... [1]

[Total: 17]

69. 9701_s17_qp_23 Q: 2

The halogens, chlorine, bromine and iodine, and their compounds, show a variety of similarities and trends in their physical and chemical properties.

(a) (i) Give the colours and states of chlorine, bromine and iodine at room temperature and pressure.

halogen	colour	state
chlorine		
bromine		
iodine		

[2]

(ii) The halogens become less volatile down the group.

Explain this trend in volatility.

.....

.....

..... [2]

(b) The halogens are oxidising agents.

State and explain the trend in oxidising power of the halogens.

.....

.....

.....

..... [3]

(c) Concentrated sulfuric acid reacts with solid sodium halides.

(i) State any observations that would be made on addition of concentrated sulfuric acid to

- solid sodium chloride, ...

.....

- solid sodium iodide. .....

.....

[2]

(ii) Give reasons for the difference in the observations in **(i)**.

.....

.....

..... [2]

(iii) The addition of concentrated sulfuric acid to solid sodium bromide, NaBr, produces brown fumes and an acidic gas that decolourises acidified potassium manganate(VII) solution. This acidic gas is a significant contributor to acid rain.

Write the equation for the reaction of concentrated sulfuric acid with sodium bromide.

..... [2]

(d) An aqueous solution, **Z**, contains a mixture of sodium chloride and sodium iodide.

(i) Excess aqueous silver nitrate is added to **Z** in a test-tube. A yellow precipitate forms.

Explain the colour of this precipitate.

.....

..... [1]

(ii) Aqueous ammonia is then added to the test-tube in **(i)**. The mass of precipitate decreases.

Explain this observation.

.....

..... [1]

[Total: 15]

11.4 The reactions of chlorine with aqueous sodium hydroxide

70. 9701_s21_qp_23 Q: 1

The elements in Group 17 are known as the halogens.

(a) Between the molecules of Group 17 elements van der Waals' forces exist.

(i) State the trend in the relative strength of van der Waals' forces down Group 17.

..... [1]

(ii) State the physical state of each of the halogens under room conditions.

chlorine .....

bromine .....

iodine .....

[1]

(b) A solution of aqueous bromide ions, Br^-(aq), is added to separate samples of Cl_2(aq) and I_2(aq).

Describe what is observed in each reaction. Explain your answer in terms of the relative reactivity of these elements as oxidising agents.

observation on addition to Cl_2(aq) .....

.....

observation on addition to I_2(aq) .....

.....

explanation .....

.....

.....

[3]

(c) Bleach is made by reacting Cl_2 with cold NaOH(aq).

Write an equation for the reaction of Cl_2 with cold NaOH.

..... [1]

(d) When $C\mathit{l}O^-$(aq) is added to water, it behaves as a Brønsted-Lowry base.

(i) Define the term *Brønsted-Lowry base*.

..... [1]

(ii) Write an ionic equation for the reaction between $C\mathit{l}O^-$ and H_2O.

..... [1]

(e) The concentration of $NaC\mathit{l}O$ in bleach **S** is $x\,g\,dm^{-3}$.

$NaC\mathit{l}O$ reacts with H_2O_2(aq) as shown.

$$H_2O_2(aq) + NaC\mathit{l}O(aq) \rightarrow H_2O(l) + NaC\mathit{l}(aq) + O_2(g)$$

A 5.00 cm^3 sample of **S** completely reacts with H_2O_2(aq). The volume of O_2(g) produced is 24.0 cm^3 under room conditions.

Assume that only the $NaC\mathit{l}O$ in **S** reacts with H_2O_2(aq).

Calculate x. Show your working.

x = ... $g\,dm^{-3}$
[3]

(f) Sodium chlorate(I), $NaC\mathit{l}O$, oxidises dilute hydrochloric acid to form three products. The products which contain chlorine have chlorine species with oxidation number –1 or 0.

No other species changes its oxidation number during the reaction.

Use this information to complete the ionic equation.

.....$C\mathit{l}O^-$ + ...$HC\mathit{l}$ $\rightarrow$ ..... + ... + ... [2]

[Total: 13]

71. 9701_s18_qp_23 Q: 3

The elements in Group 17, the halogens, show trends in both their chemical and physical properties. The elements and their compounds have a wide variety of uses.

(a) At room temperature fluorine and chlorine are gases, bromine is a liquid and iodine is a solid.

(i) State the trend in the volatility of the Group 17 elements down the group.

..... [1]

(ii) Explain this trend.

.....

.....

..... [2]

(b) Iodine, I_2, can be displaced from NaI(aq), by chlorine, Cl_2.

Write an equation for this reaction.

..... [1]

(c) Silver nitrate solution, $AgNO_3(aq)$, is added to separate solutions of NaI and NaCl. Precipitates form. An excess of aqueous ammonia is then added to both precipitates.

(i) Complete the table to give the colour and name of the precipitate formed in each reaction and the effect of the addition of an excess of aqueous ammonia to each of the precipitates formed.

	NaI(aq) + $AgNO_3(aq)$	NaCl(aq) + $AgNO_3(aq)$
colour of precipitate		
name of precipitate		
effect of addition of an excess of aqueous ammonia to the precipitate		

[3]

(ii) Write an ionic equation, including state symbols, to show the reaction occurring when $AgNO_3(aq)$ is added to NaI(aq).

..... [1]

(d) Solid NaI reacts with concentrated sulfuric acid to form purple fumes of $I_2(g)$ and hydrogen sulfide gas, $H_2S(g)$.
However, when solid NaCl reacts with concentrated sulfuric acid the only gas produced is HCl(g).

Explain the difference in the reactions of concentrated sulfuric acid with NaI and with NaCl. Your answer should refer to the role of the sulfuric acid in each reaction.

.....

.....

.....

.....

.....

..... [3]

(e) Chlorine is commonly used in water purification. When chlorine is added to water it reacts to produce a mixture of acids, one of which is chloric(I) acid, HClO, a powerful oxidising agent.

(i) Explain the meaning of the term *oxidising agent*, in terms of electron transfer.

.....

.....

..... [1]

(ii) Suggest an equation for this reaction of chlorine with water.

..... [1]

(iii) Write an equation for the reaction of chlorine with **hot** aqueous sodium hydroxide.

Use oxidation numbers to explain why this is a redox reaction.

equation .....

.....

..... [2]

[Total: 15]

11.5 Some important uses of the halogens and of halogen compounds

72. 9701_s19_qp_22 Q: 3

Period 3 elements react with chlorine gas, Cl_2(g), to form chlorides.

(a) The table shows the differences in observations which occur when two Period 3 chlorides are added to water.

Period 3 chloride	observations when added to water	pH of solution formed with water
$NaCl$	White solid disappears. Colourless solution made.	7
$SiCl_4$	Pale yellow solution forms. Bubbles form and the test-tube feels hot. White precipitate forms.	1–2

(i) Write an equation for the reaction occurring when $SiCl_4$ is added to cold water. Include state symbols.

..... [1]

(ii) Name the type of reaction occurring when $SiCl_4$ is added to water.
Ignore the exothermic/endothermic nature of the reaction.

..... [1]

(iii) Explain, in terms of bonding, why $NaCl$ and $SiCl_4$ behave differently when added to water.

.....

.....

..... [2]

(iv) Explain, in terms of electronegativity, why the bonding in $NaCl$ is different from the bonding in $SiCl_4$.

.....

.....

.....

..... [3]

(b) Cl_2(g) dissolves in cold water and reacts with it.

$$Cl_2 + H_2O \rightarrow HCl + HClO$$

(i) Identify the oxidation number of chlorine in each of the chlorine-containing species in this reaction.

chlorine-containing species	Cl_2	HCl	$HClO$
oxidation number of chlorine			

[2]

(ii) Name the type of reaction occurring.

..... [1]

(iii) Explain why chlorine is used in the purification of water.

.....

..... [1]

(c) A mixture of HCl and $HClO$ is added to cold dilute NaOH. One of the products behaves as a bleach.

Suggest the equation for the reaction occurring.

..... [2]

[Total: 13]

1.

The concepts of bond energy, bond length and bond polarity are useful when comparing the behaviour of similar molecules, e.g. thermal stability.

For example, it could be said

*"Compared with the HCl molecule, the bond .....**X**..... of the HI molecule is .....**Y**..... ."*

Which pairs of words correctly complete the above sentence?

	X	Y
1	energy	greater
2	length	greater
3	polarity	less

[2002 M/J (33)]

2.

Which sodium salts form a precipitate when $AgNO_3(aq)$ followed by dilute $NH_3(aq)$ is added to its aqueous solution?

1 chloride

2 bromide

3 iodide

[2002 M/J (37)]

3.

The element astatine lies below iodine in Group VII of the Periodic Table.

What will be the properties of astatine?

1 It forms diatomic molecules which dissociate more readily than chlorine molecules.

2 It reacts explosively with hydrogen.

3 It is a good reducing agent.

[2002 O/N (35)]

4.

Ammonia and chlorine react in the gas phase.

$$8NH_3 + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

Which statements are correct?

1 Ammonia behaves as a reducing agent.

2 Ammonia behaves as a base.

3 The oxidation number of the hydrogen changes.

[2002 O/N (36)]

5.

Chlorine compounds show oxidation states ranging from –1 to +7.

What are the reagent(s) and conditions necessary for the oxidation of elemental chlorine into a compound containing chlorine in the +5 oxidation state?

A $AgNO_3(aq)$ followed by $NH_3(aq)$ at room temperature

B concentrated H_2SO_4 at room temperature

C cold dilute NaOH(aq)

D hot concentrated NaOH(aq)

[2003 M/J (16)]

6.

Which gaseous hydride most readily decomposes into its elements on contact with a hot glass rod?

A ammonia

B hydrogen chloride

C hydrogen iodide

D steam

[2003 M/J (17)]

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7.
Why is the addition of concentrated sulphuric acid to solid potassium iodide **unsuitable** for the preparation of hydrogen iodide?

1 Hydrogen iodide is not displaced by sulphuric acid.

2 Iodide ions are oxidised to iodine.

3 The product is contaminated by sulphur compounds.

[2003 M/J (36)]

8.
In what order does the reducing power of the hydrogen halides increase?

A HC*l*, HBr, HI

B HC*l*, HI, HBr

C HBr, HI, HC*l*

D HI, HBr, HC*l*

[2003 M/J (17)]

9.
Which statement is most likely to be true for astatine, which is below iodine in Group VII of the Periodic Table?

A Astatine and aqueous potassium chloride react to form aqueous potassium astatide and chlorine.

B Potassium astatide and hot dilute sulphuric acid react to form white fumes of only hydrogen astatide.

C Silver astatide reacts with dilute aqueous ammonia in excess to form a solution of a soluble complex.

D Sodium astatide and hot concentrated sulphuric acid react to form astatine.

[2004 M/J (17)]

10.
When a hot glass rod is placed in a gas jar of hydrogen iodide, there is an immediate reaction as the hydrogen iodide decomposes.

Which statements about this reaction are correct?

1 Hydrogen iodide is purple coloured.

2 The hot rod provides the activation energy.

3 One of the products is a solid.

[2004 M/J (36)]

11.
The following report appeared in a newspaper.

> Drums of bromine broke open after a vehicle crash on the motorway. Traffic was diverted as purple gaseous bromine drifted over the road (it is denser than air), causing irritation to drivers' eyes. Firemen sprayed water over the scene of the accident, dissolving the bromine and washing it away.

What is **wrong** with the report?

A Bromine does not dissolve in water.

B Bromine does not vapourise readily.

C Bromine is less dense than air.

D Bromine is not purple.

[2004 O/N (17)]

12.
Which properties in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide steadily increase?

1 thermal stability

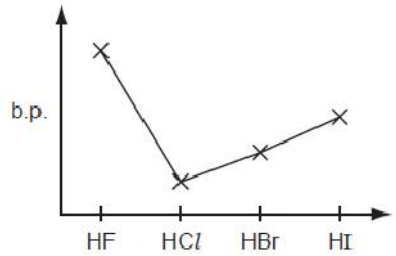
2 bond length

3 ease of oxidation

[2004 O/N (36)]

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13.
The diagram shows the variation of the boiling points of the hydrogen halides.



What explains the higher boiling point of hydrogen fluoride?

A The bond energy of HF molecules is greater than in other hydrogen halides.

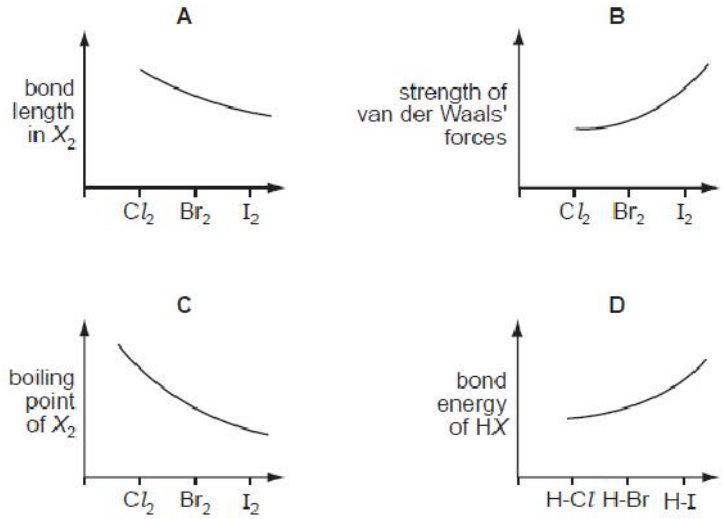
B The effect of nuclear shielding is much reduced in fluorine which polarises the HF molecule.

C The electronegativity of fluorine is much higher than for other elements in the group.

D There is hydrogen bonding between HF molecules.

[2005 M/J (5)]

14.
Which graph correctly describes a trend found in the halogen group?



[2005 M/J (16)]

15.
What happens when chlorine is bubbled through aqueous potassium iodide?

A Chlorine is oxidised to chloride ions.

B Hydrochloric acid is formed.

C Iodide ions are oxidised to iodine.

D Potassium iodide is reduced to iodine.

[2006 M/J (17)]

16.
Which of the following is **not** a correct statement about iodine?

A A crystal of iodine contains covalent bonds and van der Waals' forces.

B Iodine vapour is purple.

C The first ionisation energy of iodine is less than that of bromine.

D The hydride of iodine is of greater thermal stability than that of bromine.

[2006 O/N (15)]

17.
Mixing aqueous silver nitrate and aqueous sodium chloride produces a precipitate.

Addition of which reagent to the mixture gives a colourless solution?

A aqueous ammonia

B aqueous potassium iodide

C dilute hydrochloric acid

D dilute nitric acid

[2006 O/N (16)]

18.
Which is the complete list of all the products from the reaction of concentrated sulphuric acid with potassium bromide?

A potassium hydrogensulphate and hydrogen bromide

B potassium hydrogensulphate, hydrogen bromide and bromine

C potassium hydrogensulphate, hydrogen bromide, bromine and water

D potassium hydrogensulphate, hydrogen bromide, bromine, water and sulphur dioxide

[2006 O/N (17)]

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19.

Use of the Data Booklet is relevant to this question.

The element astatine lies below iodine in Group VII of the Periodic Table.

What will be the properties of astatine?

1 It forms diatomic molecules which dissociate more readily than chlorine molecules.

2 It reacts explosively with hydrogen.

3 It is a good reducing agent.

[2007 M/J (36)]

20.

Gaseous nitrogen is less reactive than gaseous fluorine.

What is the reason for this difference in reactivity?

A The boiling point of nitrogen is lower than that of fluorine.

B The relative molecular mass of nitrogen is lower than that of fluorine.

C The atomic radius of nitrogen is greater than that of fluorine.

D The bond strength in the molecule is greater in nitrogen than in fluorine.

[2007 O/N (18)]

21.

Why is the addition of concentrated sulphuric acid to solid potassium iodide **unsuitable** for the preparation of hydrogen iodide?

1 Hydrogen iodide is not displaced by sulphuric acid.

2 Iodide ions are oxidised to iodine.

3 The product is contaminated by sulphur compounds.

[2007 O/N (36)]

22.

Properties of chlorine, iodine and their compounds are compared.

Property **Q** for chlorine is smaller than for iodine.

What is property **Q**?

A oxidising ability of the element

B solubility of the silver halide in $NH_3(aq)$

C strength of van der Waals' forces between the molecules of the element

D thermal stability of the hydrogen halide

[2008 M/J (16)]

23.

A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulphuric acid and concentrated phosphoric acid. The observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

A Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulphuric acid.

B Concentrated phosphoric acid is a stronger oxidising agent than iodine.

C Concentrated sulphuric acid is a stronger oxidising agent than chlorine.

D Concentrated sulphuric acid is a stronger oxidising agent than iodine.

[2008 O/N (17)]

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24.

Chlorine is a greenish-yellow gas, bromine is a dark red liquid and iodine is a dark grey solid.

What causes these differences in volatility?

1 the halogen-halogen bond energy

2 the magnitude of the van der Waals' forces between the molecules

3 the number of electrons in the halogen molecule

[2008 O/N (35)]

25.

A crystal of iodine produces a purple vapour when gently heated.

Which pair of statements correctly describes this process?

	type of bond broken	formula of purple species
A	covalent	I
B	covalent	I_2
C	induced dipole-dipole	I_2
D	permanent dipole-dipole	I_2

[2009 M/J (7)]

26.

Over half a million tonnes of bromine are manufactured annually and are mainly used for making other compounds. One important use is for agricultural chemicals.

What is another important use for bromine?

A antiseptic agents

B bleaches for textiles and the paper industry

C flame-retardants and fire extinguishers

D water purification

[2009 M/J (14)]

27.

Which statement is most likely to be true for astatine, which is below iodine in Group VII of the Periodic Table?

A Astatine and aqueous potassium chloride react to form aqueous potassium astatide and chlorine.

B Potassium astatide and hot dilute sulfuric acid react to form white fumes of only hydrogen astatide.

C Silver astatide reacts with dilute aqueous ammonia in excess to form a solution of a soluble complex.

D Sodium astatide and hot concentrated sulfuric acid react to form astatine.

[2009 M/J (16)]

28.

Which properties in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide steadily increase?

1 thermal stability

2 bond length

3 ease of oxidation

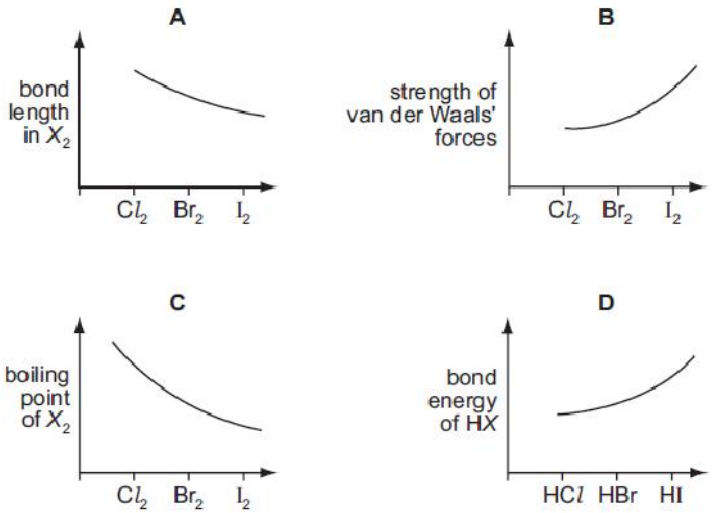
[2009 M/J (36)]

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29.

Which graph correctly describes a trend found in the halogen group?

[*X* represents a halogen atom.]



[2009 O/N-11 (15)]

30.

Which statements about the reaction of solid sodium bromide with concentrated sulfuric acid are correct?

1 Hydrogen bromide is a product of the reaction.

2 Sulfuric acid is oxidised to sulfur dioxide.

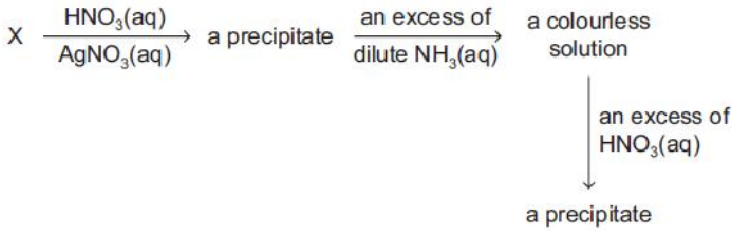
3 Bromide ions are reduced to bromine.

[2009 O/N-11 (36)]

31.

X is a salt of one of the halogens chlorine, bromine, iodine, or astatine (proton number 85).

The reaction scheme shows a series of reactions using a solution of X as the starting reagent.



What could X be?

A sodium chloride

B sodium bromide

C potassium iodide

D potassium astatide

[2010 M/J-11 (14)]

32.

Chile saltpetre, $NaNO_3$, contains sodium iodide as an impurity.

Aqueous silver nitrate is added to an aqueous solution of Chile saltpetre. Concentrated aqueous ammonia is then added.

Which observations are made?

	with acidified silver nitrate	with concentrated aqueous ammonia
A	no precipitate	no further reaction
B	no precipitate	precipitate forms
C	precipitate forms	precipitate dissolves
D	precipitate forms	precipitate remains

[2010 O/N-11 (16)]

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33.
Which statement describes the halogens chlorine, bromine and iodine?

A Their bond energies decrease with increasing proton number.

B Their first ionisation energies increase with increasing proton number.

C They are all coloured gases at room temperature.

D They are all good reducing agents.

[2010 O/N-11 (17)]

34.
What happens when chlorine is bubbled through aqueous potassium iodide?

A Chlorine is oxidised to chlorate(V) ions.

B Chlorine is oxidised to chloride ions.

C Iodide ions are oxidised to iodine.

D There is no observable reaction.

[2010 O/N-12 (16)]

35.
Which statement about bromine is correct?

A Bromine is insoluble in non-polar solvents.

B Bromine vapour is more dense than air.

C Bromine will not vapourise significantly under normal conditions.

D Gaseous bromine is purple.

[2010 O/N-12 (18)]

36.
Concentrated sulfuric acid reacts with both solid sodium chloride at room temperature and with solid sodium iodide at room temperature.

Which row correctly describes how concentrated sulfuric acid behaves in each of these reactions?

	with sodium chloride	with sodium iodide
A	as an oxidising agent only	as an oxidising agent only
B	as a strong acid and as an oxidising agent	as a strong acid only
C	as a strong acid only	as a strong acid and as an oxidising agent
D	as a strong acid only	as a strong acid only

[2010 O/N-12 (19)]

37.
X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2, Y_2 and Z_2 were separately added to separate aqueous solutions containing X^-, Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row in the following table contains the ions X^-, Y^- and Z^- in order of their decreasing strength as reducing agents?

	strongest ⟶		weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

[2011 M/J-11 (15)]

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38.
A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. The observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

A Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.

B Concentrated phosphoric acid is a stronger oxidising agent than iodine.

C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.

D Concentrated sulfuric acid is a stronger oxidising agent than iodine.

[2011 M/J-11 (16)]

39.
Which statements are correct?

1 Aluminium chloride dissolves in water to give an acidic solution.

2 Magnesium chloride dissolves in water to give a slightly acidic solution.

3 Sodium chloride dissolves in water to give an alkaline solution.

[2011 M/J-11 (34)]

40.
Use of the Data Booklet is relevant to this question.

The element astatine lies below iodine in Group VII of the Periodic Table.

What will be the properties of astatine?

1 It forms diatomic molecules which dissociate more readily than chlorine molecules.

2 It reacts explosively with hydrogen.

3 It can oxidise iodide to iodine.

[2011 M/J-11 (36)]

41.
Why do the halogens become less volatile as Group VII is descended?

A The halogen-halogen bond energy decreases.

B The halogen-halogen bond length increases.

C The number of electrons in each molecule increases.

D The van der Waals' forces between molecules become weaker.

[2011 O/N-11 (17)]

42.
Which of the halide ions, chloride, bromide or iodide, acts as a reducing agent when its sodium salt reacts with concentrated sulfuric acid?

1 at least one of Cl^-, Br^- and I^-

2 at least two of Cl^-, Br^- and I^-

3 all three of Cl^-, Br^- and I^-

[2011 O/N-11 (35)]

43.
What trend is observed on descending Group VII?

A The colours of the elements become lighter.

B The elements become more volatile.

C The hydrides of the elements become more thermally stable.

D The reactions of the elements with hydrogen become less vigorous.

[2012 M/J-11 (17)]

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44.

The following two experiments are carried out with anhydrous potassium chloride and observations X and Y are made at the end of each experiment.

Concentrated sulfuric acid is added to the potassium chloride and the fumes produced are bubbled into aqueous potassium iodide solution - observation X.

The potassium chloride is dissolved in aqueous ammonia and this is then added to aqueous silver nitrate - observation Y.

What are the observations X and Y?

	X	Y
A	brown solution	colourless solution
B	brown solution	white precipitate
C	colourless solution	colourless solution
D	colourless solution	white precipitate

[2012 M/J-11 (18)]

45.

Which statements are correct for all three halogens, chlorine, bromine and iodine?

1 They all form hydrides that are strong acids in aqueous solution.

2 They all react with aqueous sodium hydroxide to form oxo-anions.

3 They all require one more electron to fill the p orbitals of their outer shells.

[2012 M/J-11 (35)]

46.

Chlorine shows oxidation states ranging from –1 to +7 in its compounds.

What are the reagent(s) and conditions necessary for the oxidation of elemental chlorine into a compound containing chlorine in the +5 oxidation state?

A $AgNO_3(aq)$ followed by $NH_3(aq)$ at room temperature

B concentrated H_2SO_4 at room temperature

C cold dilute NaOH(aq)

D hot concentrated NaOH(aq)

[2012 M/J-12 (16)]

47.

Silver chloride dissolves in aqueous ammonia.

What happens in this process?

1 A co-ordinate bond is formed.

2 The oxidation number of nitrogen is unchanged.

3 Ammonia acts as a Brønsted-Lowry base.

[2012 M/J-12 (34)]

48.

Compared with the HC*l* molecule, the bond .....**X**..... of the HBr molecule is .....**Y**.....

Which pairs of words correctly complete the above sentence?

	X	Y
1	energy	less
2	polarity	less
3	length	greater

[2012 M/J-12 (35)]

49.

The element astatine, At, is below iodine in Group VII of the Periodic Table.

Which statements concerning At will be correct?

1 It is a dark-coloured solid at room temperature.

2 It is a more powerful oxidising agent than iodine.

3 Its hydride is thermally stable.

[2012 O/N-11 (34)]

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50.
What happens when iodine solution is added to a solution of sodium bromide?

A A reaction occurs without changes in oxidation state.

B Bromide ions are oxidised, iodine atoms are reduced.

C Bromide ions are reduced, iodine atoms are oxidised.

D No reaction occurs.

[2013 M/J-11 (14)]

51.
Element 85, astatine, is in Group VII. Concentrated sulfuric acid is added to sodium astatide. The mixture of products includes astatine, hydrogen astatide, hydrogen sulfide, and sodium sulfate.

Which product is formed by the oxidation of one of the constituents of sodium astatide?

A astatine

B hydrogen astatide

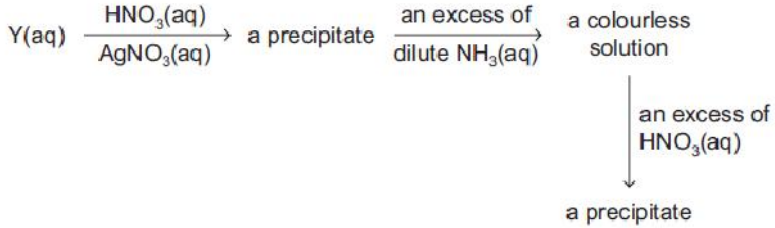
C hydrogen sulfide

D sodium sulfate

[2013 M/J-11 (15)]

52.
Y is a salt of one of the halogens chlorine, bromine, iodine, or astatine (element 85).

The reaction scheme shows a series of reactions using a solution of Y as the starting reagent.



What could Y be?

A sodium chloride

B sodium bromide

C potassium iodide

D potassium astatide

[2013 M/J-11 (17)]

53.
When a red-hot platinum wire is plunged into a test tube of hydrogen iodide, the gas is decomposed into its elements. If the experiment is repeated with hydrogen chloride, no change occurs.

Which factors contribute to this behaviour?

1 the strength of the hydrogen-halogen bond

2 the size of the halogen atom

3 the standard enthalpy of formation, $\Delta H_f^\ominus$, of each of the products of decomposition

[2013 M/J-11 (36)]

54.
Many modern cars are fitted with halogen lamps. When such lamps are first switched on, a distinct purple colour can be seen.

Which species is responsible for this purple colour?

A $I_2(s)$ **B** $I_2(l)$ **C** $I_2(g)$ **D** $I(g)$

[2013 M/J-12 (15)]

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55.
What happens when bromine solution is added to a solution of sodium iodide?

A A reaction occurs without changes in oxidation state.

B Bromine atoms are oxidised, iodide ions are reduced.

C Bromine atoms are reduced, iodide ions are oxidised.

D No reaction occurs.

[2013 M/J-12 (18)]

56.
The halogens exist as diatomic molecules, X_2.

The boiling points of the Group VII elements increase as the group is descended from chlorine to iodine.

Which statement helps to explain this increase in boiling point as Group VII is descended?

A The electronegativity of X decreases as the group is descended.

B The number of electrons in each X_2 molecule increases as the group is descended.

C The size of the permanent dipole in the X_2 molecule increases as the group is descended.

D The X–X bond strength increases as the group is descended.

[2013 M/J-12 (19)]

57.
Which properties increase in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide?

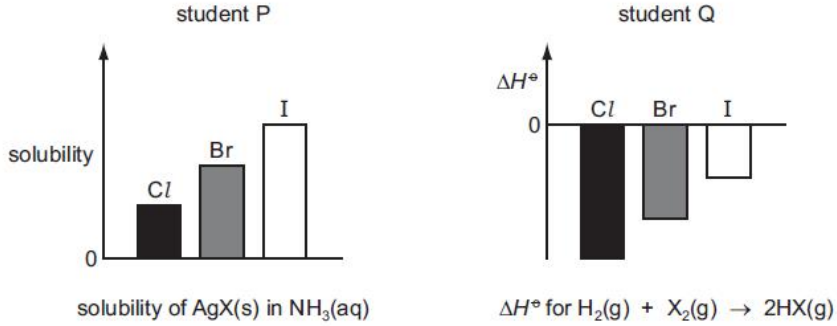
1 thermal stability

2 bond length

3 ease of oxidation

[2013 M/J-12 (35)]

58.
Two students, P and Q, were asked to draw bar charts to represent how some properties of the halogens and their compounds differ in magnitude. Their diagrams are shown.



solubility of AgX(s) in $NH_3(aq)$ $\Delta H^\ominus$ for $H_2(g) + X_2(g) \rightarrow 2HX(g)$

Which of the student's diagrams are correct?

A both P and Q

B P only

C Q only

D neither P nor Q

[2013 M/J-13 (14)]

59.
When iodine is heated, a vapour is produced.

Which row of the table correctly identifies the species in the vapour and its colour?

	species	colour
A	I(g)	brown
B	I(g)	purple
C	$I_2(g)$	brown
D	$I_2(g)$	purple

[2013 M/J-13 (15)]

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60.
How do the strengths of the covalent bonds within molecules, and the van der Waals' forces between molecules, vary going down Group VII from chlorine to bromine to iodine?

	strength of covalent bonds	strength of van der Waals' forces
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

[2013 M/J-13 (16)]

61.
Solid potassium halides react with concentrated sulfuric acid, according to the following equations.

reaction 1 $2KCl + H_2SO_4 \rightarrow K_2SO_4 + 2HCl$

reaction 2 $2KBr + 2H_2SO_4 \rightarrow K_2SO_4 + SO_2 + Br_2 + 2H_2O$

reaction 3 $8KI + 5H_2SO_4 \rightarrow 4K_2SO_4 + H_2S + 4I_2 + 4H_2O$

What is the largest **change** in the oxidation number of sulfur in each of these reactions?

	reaction 1	reaction 2	reaction 3
A	0	0	4
B	0	2	4
C	0	2	8
D	0	4	8

[2013 O/N-11 (16)]

62.
Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions have the same number of electrons.

D The NH_4^+ ion can donate a proton.

[2013 O/N-11 (17)]

63.
Redox reactions occur very frequently in the chemistry of Group VII.

Which statement is correct?

A Chlorine will oxidise bromide ions but not iodide ions.

B Fluorine is the weakest oxidising agent out of F_2, Cl_2, Br_2 and I_2.

C Iodide ions are the weakest reducing agent out of F^-, Cl^-, Br^- and I^-.

D When chlorine reacts with water, chlorine is both oxidised and reduced.

[2014 M/J-11 (12)]

64.
A test-tube of HI gas and a test-tube of HBr gas are placed together in an environment at temperature, T.

Which combinations of observations are possible depending on the temperature, T?

1 A brown vapour appears in one of the test-tubes. No change is apparent in the other test-tube.

2 A brown vapour appears in one of the test-tubes. A purple vapour appears in the other test-tube.

3 No change is apparent in either test-tube.

[2014 M/J-11 (36)]

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65.

When solid sodium iodide reacts with concentrated sulfuric acid, the products include $NaHSO_4$, H_2S, SO_2 and S.

In the formation of which product has the oxidation state of sulfur changed by a value of 8?

A H_2S **B** $NaHSO_4$ **C** S **D** SO_2

[2014 M/J-12 (17)]

66.

Use of the Data Booklet is relevant to this question.

In an experiment, 0.125 mol of chlorine gas, Cl_2, is reacted with an excess of cold aqueous sodium hydroxide. One of the products is a compound of sodium, oxygen, and chlorine.

Which mass of this product is formed?

A 9.31 g **B** 13.3 g **C** 18.6 g **D** 26.6 g

[2014 M/J-12 (19)]

67.

The intermolecular forces between iodine molecules are instantaneous dipole-induced dipole forces.

Which statements explain why iodine has these intermolecular forces?

1 An iodine molecule is polar and experiences an attraction from a lone pair of electrons on an adjacent molecule.

2 An iodine molecule has a fluctuating dipole because the electrons in a molecule are more mobile than the nuclei.

3 The electron charge cloud within an I_2 molecule may become unsymmetrical and may then attract other I_2 molecules.

[2014 M/J-13 (36)]

68.

Chlorine gas reacts with cold aqueous sodium hydroxide. It can also react with hot aqueous sodium hydroxide.

What are the oxidation numbers of chlorine in the products of these reactions?

	cold aqueous sodium hydroxide	hot aqueous sodium hydroxide
A	–1, +1	–1, +5
B	–1, +1	+1, +6
C	–1, +2	–1, +5
D	–1, +2	+1, +6

[2014 O/N-11 (16)]

69.

Under standard conditions, which statement is correct?

A $Cl^-(aq)$ can oxidise $Br_2(aq)$.

B $Cl^-(aq)$ can reduce $Br_2(aq)$.

C $Cl_2(aq)$ can oxidise $Br^-(aq)$.

D $Cl_2(aq)$ can reduce $Br^-(aq)$.

[2014 O/N-11 (17)]

70.

On being heated, hydrogen iodide breaks down more quickly than hydrogen chloride.

Which statements explain this faster rate?

1 The HI bond is weaker than the HCl bond.

2 The reaction of the breakdown of HI has a smaller activation energy than that of HCl.

3 The breakdown of HI is more exothermic than that of HCl.

[2014 O/N-11 (35)]

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71.
A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water. Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was added, the precipitate partly dissolved leaving a darker yellow precipitate.

What might the powder have consisted of?

A sodium bromide only

B sodium iodide only

C a mixture of sodium chloride and sodium bromide

D a mixture of sodium chloride and sodium iodide

[2014 O/N-13 (15)]

72.
In a solution that contains both Br_2 and Cl_2, a process takes place that produces BrO_3^- ions.

The process is represented by the following equations.

equation 1 $Br_2 + H_2O \rightarrow HBr + HBrO$

equation 2 $3HBrO + Cl_2 \rightarrow 2Cl^- + BrO_3^- + Br_2 + 3H^+$

Which statements about these reactions are correct?

1 Chlorine is reduced in equation 2.

2 Bromine is oxidised in both equation 1 and equation 2.

3 Bromine is reduced in both equation 1 and equation 2.

[2014 O/N-13 (31)]

73.
Compared with the HI molecule, the bond ……P…… of the HBr molecule is ……Q……

Which pairs of words correctly complete the above sentence?

	P	Q
1	energy	greater
2	length	less
3	polarity	greater

[2014 O/N-13 (35)]

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Group 17 – 2021 AS

1. Nov/2021/Paper_11/No.14

In which list are all three compounds soluble in water?

A barium chloride, calcium carbonate, magnesium hydroxide

B barium hydroxide, calcium hydroxide, strontium carbonate

C barium chloride, barium hydroxide, magnesium sulfate

D barium sulfate, calcium sulfate, magnesium hydroxide

2. Nov/2021/Paper_11/No.16

In a series of nine experiments, to test the reactivity of the halogens, an aqueous solution of each halogen is added to an equal volume of an aqueous solution containing halide ions, as shown in the table.

halogen solution	halide solution		
	sodium chloride (aq)	sodium bromide (aq)	sodium iodide (aq)
chlorine (aq)	experiment 1	experiment 2	experiment 3
bromine (aq)	experiment 4	experiment 5	experiment 6
iodine (aq)	experiment 7	experiment 8	experiment 9

The nine resulting mixtures are then shaken separately with an equal volume of hexane. The nine tubes are left to stand so that the aqueous and organic solvents separate into layers.

How many test-tubes contain a purple upper hexane layer?

A 1 **B** 2 **C** 3 **D** 5

3. Nov/2021/Paper_12/No.15

Redox reactions are common in the chemistry of Group 17 elements.

Which statement is correct?

A Br^- ions will reduce Cl_2 but not I_2.

B Cl_2 will oxidise Br^- ions but not I^- ions.

C F_2 is the weakest oxidising agent out of F_2, Cl_2, Br_2 and I_2.

D I^- ions are the weakest reducing agent out of F^-, Cl^-, Br^- and I^-.

4. Nov/2021/Paper_12/No.18

Oxides of nitrogen are present in the environment due to natural and man-made sources.

Which row is correct?

	natural source of nitrogen oxides	man-made source of nitrogen oxides
A	electrical discharges in the atmosphere	internal combustion engines
B	electrical discharges in the atmosphere	as a by-product of the Haber process
C	decomposition of dead plants in rivers	internal combustion engines
D	decomposition of dead plants in rivers	as a by-product of the Haber process

5. Nov/2021/Paper_13/No.16

In a series of nine experiments, to test the reactivity of the halogens, an aqueous solution of each halogen is added to an equal volume of an aqueous solution containing halide ions, as shown in the table.

halogen solution	halide solution		
	sodium chloride (aq)	sodium bromide (aq)	sodium iodide (aq)
chlorine (aq)	experiment 1	experiment 2	experiment 3
bromine (aq)	experiment 4	experiment 5	experiment 6
iodine (aq)	experiment 7	experiment 8	experiment 9

The nine resulting mixtures are then shaken separately with an equal volume of hexane. The nine tubes are left to stand so that the aqueous and organic solvents separate into layers.

How many test-tubes contain a purple upper hexane layer?

A 1 **B** 2 **C** 3 **D** 5

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6. March/2021/Paper_12/No.16

Chlorine gas is reacted with aqueous sodium hydroxide. The oxidation number of chlorine changes from 0 to –1 and also from 0 to +1.

Under which conditions does this reaction occur and what is the colour of the solid silver salt with chlorine in the oxidation state –1?

	reaction conditions	colour of silver salt
A	cold, dilute alkali	white
B	cold, dilute alkali	yellow
C	hot, concentrated alkali	white
D	hot, concentrated alkali	yellow

7. March/2021/Paper_12/No.17

When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.

Which statement is correct?

A Hydrogen sulfide is the product of a reduction reaction.

B Iodide ions are stronger oxidising agents than sulfate ions.

C Sulfur atoms from the sulfuric acid are both oxidised and reduced.

D Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

8. March/2021/Paper_22/No.2

Chlorine, Cl_2, is a reactive yellow-green gas. It is a strong oxidising agent.

(a) State how Cl_2 is used in water purification.

.....

..... [1]

(b) Chlorine has the highest first ionisation energy of the Period 3 elements Na to Cl.

(i) Construct an equation for the first ionisation energy of chlorine.

Include state symbols.

..... [1]

(ii) Explain the general increase in the first ionisation energies of the Period 3 elements.

.....

.....

.....

..... [2]

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(c) The halide ions, X^- (where X = C*l*, Br, I), show clear trends in their physical and chemical properties.

(i) State and explain the relative thermal stabilities of the hydrogen halides, HX.

.....

.....

..... [2]

The halide ions react easily with concentrated H_2SO_4.

The main sulfur-containing product of each reaction is shown in the table.

halide ion	Cl^-	Br^-	I^-
main sulfur-containing product of reaction with concentrated H_2SO_4	HSO_4^-	SO_2	H_2S
oxidation number of sulfur			

(ii) Complete the table to show the oxidation number of sulfur in each of the sulfur-containing products. [1]

(iii) Explain why different sulfur-containing products are produced when each of these halide ions reacts with concentrated H_2SO_4.

.....

..... [1]

(d) Cl_2 reacts with aqueous sodium hydroxide in a disproportionation reaction.

(i) State what is meant by *disproportionation*.

.....

..... [1]

(ii) Write an equation for the reaction of Cl_2 with cold aqueous sodium hydroxide.

..... [1]

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(e) Aluminium reacts with chlorine to form aluminium chloride.

Aluminium chloride can exist as the gaseous molecule Al_2Cl_6(g). This molecule contains coordinate bonds.

(i) Draw a diagram that clearly shows all the types of bond present in Al_2Cl_6(g).

[2]

(ii) Describe what you would see when solid aluminium chloride reacts with water.

Name the type of reaction that occurs.

.....

.....

..... [2]

(f) 0.020 mol of element **Z** reacts with excess Cl_2 to form 0.020 mol of a liquid chloride.

The liquid chloride has formula **Z**Cl_n, where *n* is an integer.

ZCl_n reacts vigorously with water at room temperature to give an acidic solution and a white solid.

When excess $AgNO_3$(aq) is added to the solution, 11.54 g of AgCl(s) forms.

(i) Suggest the type of bonding and structure shown by **Z**Cl_n.

..... [1]

(ii) Calculate the value of *n* in **Z**Cl_n.

n = ... [2]

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(g) Dichloromethane, CH_2Cl_2, is widely used as an organic solvent.

CH_2Cl_2 can be prepared by reacting CH_3Cl and Cl_2 at room temperature.

The reaction proceeds via several steps, as shown.

$$Cl_2 \xrightarrow{\text{initiation}} 2Cl^{\bullet}$$

$$Cl^{\bullet} + CH_3Cl \xrightarrow{\text{propagation 1}} HCl + {}^{\bullet}CH_2Cl$$

$$Cl_2 + {}^{\bullet}CH_2Cl \xrightarrow{\text{propagation 2}} \text{products}$$

$$Cl^{\bullet} + {}^{\bullet}CH_2Cl \xrightarrow{\text{final step}} CH_2Cl_2$$

(i) Give the name of the mechanism of this reaction.

..... [1]

(ii) State the essential condition required for the initiation step to take place.

..... [1]

(iii) Give the electronic configuration of $Cl^{\bullet}$.

$1s^2$ ..... [1]

(iv) Identify the products of the step labelled propagation 2.

..... [1]

(v) Name the type of reaction shown in the final step.

..... [1]

(vi) Suggest the identity of another organic molecule that is a product of the reaction of CH_3Cl and Cl_2 under the same conditions.

..... [1]

[Total: 23]

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9. June/2021/Paper_11/No.17

The volatility of the Group 17 elements, chlorine, bromine and iodine, decreases down the group.

What is responsible for this trend?

A bond length in the halogen molecule

B bond strength in the halogen molecule

C electronegativity of the halogen atom

D number of electrons in the halogen atom

10. June/2021/Paper_12/No.12

A sample of $SiCl_4$ is added to cold water.

Which statement describes the mixture formed at the end of the reaction?

A acidic solution with no precipitate

B acidic solution with white precipitate

C neutral solution with no precipitate

D neutral solution with white precipitate

11. June/2021/Paper_12/No.16

Which row gives mixtures that **both** result in the oxidation of a halide ion?

	mixture 1	mixture 2
A	$AgNO_3(aq)$ and $NaCl(aq)$	concentrated $H_2SO_4(aq)$ and $HI(aq)$
B	$Br_2(aq)$ and $NaCl(aq)$	concentrated $H_2SO_4(aq)$ and $HCl(aq)$
C	$Cl_2(aq)$ and $NaBr(aq)$	$CH_3CHBrCH_3(l)$ + NaOH (ethanolic)
D	$Br_2(aq)$ and $NaI(aq)$	concentrated $H_2SO_4(aq)$ and $NaBr(s)$

12. June/2021/Paper_12/No.17

Chlorine gas is widely used to treat contaminated water.

When chlorine is added to water, which chemical species present is responsible for killing bacteria?

A ClO_2^- **B** Cl^- **C** HCl **D** ClO^-

13. June/2021/Paper_13/No.15

When descending Group 17 from chlorine to iodine, which statement is correct?

A The hydrides become less thermally stable as they become weaker reducing agents.

B The hydrides become more thermally stable as the reactivity of the elements decreases.

C The volatility of the elements decreases as the van der Waals' forces increase.

D The volatility of the elements increases as the size of the molecules increases.

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14. June/2021/Paper_13/No.16

A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water.

Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was then added, this precipitate partly dissolved leaving a darker yellow precipitate.

What could the powder be?

A sodium bromide only

B sodium iodide only

C a mixture of sodium chloride and sodium bromide

D a mixture of sodium chloride and sodium iodide

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15. June/2021/Paper_23/No.1

The elements in Group 17 are known as the halogens.

(a) Between the molecules of Group 17 elements van der Waals' forces exist.

(i) State the trend in the relative strength of van der Waals' forces down Group 17.

..... [1]

(ii) State the physical state of each of the halogens under room conditions.

chlorine .....

bromine .....

iodine .....

[1]

(b) A solution of aqueous bromide ions, $Br^-(aq)$, is added to separate samples of $Cl_2(aq)$ and $I_2(aq)$.

Describe what is observed in each reaction. Explain your answer in terms of the relative reactivity of these elements as oxidising agents.

observation on addition to $Cl_2(aq)$ .....

.....

observation on addition to $I_2(aq)$ .....

.....

explanation .....

.....

.....

[3]

(c) Bleach is made by reacting Cl_2 with cold NaOH(aq).

Write an equation for the reaction of Cl_2 with cold NaOH.

..... [1]

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(d) When $C\ell O^-(aq)$ is added to water, it behaves as a Brønsted-Lowry base.

(i) Define the term *Brønsted-Lowry base*.

..... [1]

(ii) Write an ionic equation for the reaction between $C\ell O^-$ and H_2O.

..... [1]

(e) The concentration of $NaC\ell O$ in bleach **S** is $x\,g\,dm^{-3}$.

$NaC\ell O$ reacts with $H_2O_2(aq)$ as shown.

$$H_2O_2(aq) + NaC\ell O(aq) \rightarrow H_2O(l) + NaC\ell(aq) + O_2(g)$$

A $5.00\,cm^3$ sample of **S** completely reacts with $H_2O_2(aq)$. The volume of $O_2(g)$ produced is $24.0\,cm^3$ under room conditions.

Assume that only the $NaC\ell O$ in **S** reacts with $H_2O_2(aq)$.

Calculate x. Show your working.

x = ... $g\,dm^{-3}$
[3]

(f) Sodium chlorate(I), $NaC\ell O$, oxidises dilute hydrochloric acid to form three products. The products which contain chlorine have chlorine species with oxidation number –1 or 0.

No other species changes its oxidation number during the reaction.

Use this information to complete the ionic equation.

.....$C\ell O^-$ + ...$HC\ell$ → ..... + ... + ... [2]

[Total: 13]

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Group 17 – 2022 June AS Chemistry 9701

1. June/2022/Paper_11/No.12

In the treatment of domestic water supplies, chlorine is added to water to kill bacteria. Some ClO^- ions are formed.

What is the change in oxidation number of chlorine when forming the ClO^- ion from aqueous chlorine?

A –1 **B** 0 **C** +1 **D** +2

2. June/2022/Paper_11/No.22

The results of tests performed on a white crystalline solid, X, are given in the table.

reagent and conditions	observation
X is gently heated	X sublimes
X is shaken with H_2O	a colourless solution, Y, forms
Y is warmed with NaOH(aq)	a gas is given off
$AgNO_3$(aq) is added to Y	a white precipitate, Z, forms
Z is shaken with NH_3(aq)	a colourless solution forms

What is the identity of X?

A aluminium bromide

B aluminium chloride

C ammonium bromide

D ammonium chloride

3. June/2022/Paper_11/No.23

Silicon is heated in an excess of chlorine, producing compound J.

An excess of water is added to the sample of J produced.

Which row is correct?

	structure of J	Is HCl produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

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4. June/2022/Paper_12/No.22

X, Y and Z are three elements in Group 17.

X_2 has weaker covalent bonds than Y_2.

X_2 has stronger instantaneous dipole–induced dipole forces between its molecules than Z_2.

Y_2 is a stronger oxidising agent than Z_2.

What could be X, Y and Z?

	X	Y	Z
A	Br	Cl	I
B	Cl	Br	I
C	I	Br	Cl
D	I	Cl	Br

5. June/2022/Paper_12/No.23

Chlorine reacts with aqueous sodium hydroxide forming two chlorine-containing products.

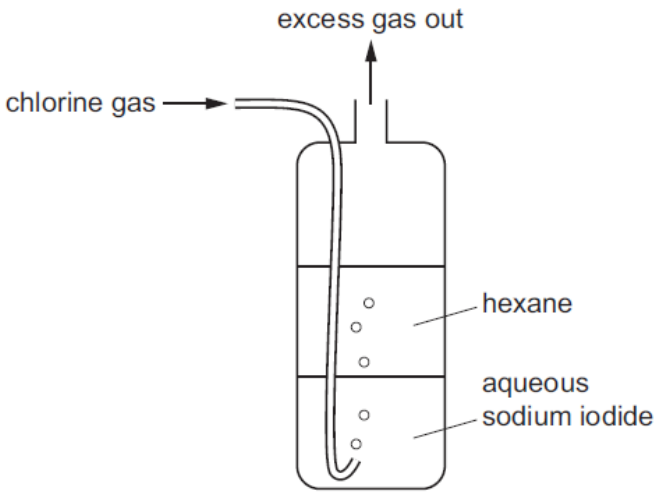
Which row shows the oxidation states of chlorine in the products under the conditions stated?

	conditions	oxidation state of Cl in products
A	cold NaOH(aq)	–1 and +3
B	cold NaOH(aq)	–1 and +5
C	hot NaOH(aq)	–1 and +3
D	hot NaOH(aq)	–1 and +5

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6. June/2022/Paper_13/No.22

Chlorine is bubbled through a cylinder containing aqueous sodium iodide and an immiscible layer of hexane.



As the bubbles pass through the cylinder, what is observed in the lower and upper layers?

	lower aqueous layer	upper hexane layer
A	colourless solution becomes brown	colourless liquid becomes coloured
B	colourless solution becomes brown	colourless liquid is unchanged
C	brown solution becomes colourless	colourless liquid becomes coloured
D	brown solution becomes colourless	colourless liquid is unchanged

7. June/2022/Paper_13/No.23

Chlorine and bromine have different volatilities.

Which row identifies the more volatile of the two elements, and gives the correct explanation?

	identity of the more volatile element	explanation for the difference in volatility
A	bromine	intermolecular forces are greater in bromine than they are in chlorine
B	bromine	intermolecular forces are greater in chlorine than they are in bromine
C	chlorine	intermolecular forces are greater in bromine than they are in chlorine
D	chlorine	intermolecular forces are greater in chlorine than they are in bromine

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8. June/2022/Paper_22/No.2(d)

(d) A sample of aqueous calcium halide, $CaX_2(aq)$, contains either chloride, bromide or iodide ions.

Complete Table 2.1 to describe a two-step process that could be used to identify the halide ion present.

Table 2.1

step	method	observation with $CaCl_2$	observation with $CaBr_2$	observation with CaI_2
step 1				
step 2				

[3]

9. June/2022/Paper_23/No.2(b)

(b) Tennessine, Ts, is an unstable man-made element. It is found below astatine, At, in Group 17. The chemical properties of Ts and its compounds have only been predicted.

(i) Suggest an equation for the reaction of NaTs and Br_2. Assume that Ts follows the same trends as the other elements in Group 17. Explain your answer.

equation .....

explanation .....

.....

[2]

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(ii) Some scientists predict that Ts has properties typical of metals like copper.

Complete Table 2.2 with:

- the predicted melting point of tennessine
- the lattice structure of solid chlorine, bromine and tennessine.

Assume that Ts has properties typical of metals like copper.

Table 2.2

element	chlorine	bromine	tennessine
melting point / °C	–101	–7.2	
lattice structure of crystalline solid			

[2]

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Group 17 – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.21

Which statement about Group 17 elements and compounds is correct?

A Sodium chloride produces chlorine when reacted with concentrated sulfuric acid.

B Sodium chloride produces chlorine when reacted with bromine.

C Sodium bromide produces bromine when reacted with concentrated sulfuric acid.

D Sodium bromide produces bromine when reacted with iodine in aqueous potassium iodide.

2. Nov/2022/Paper_11/No.22

Chlorine is bubbled through 100 cm^3 of hot 4.0 mol dm^{-3} sodium hydroxide until the reaction is complete.

$$6NaOH(aq) + xCl_2(aq) \rightarrow yNaCl(aq) + zNaClO_3(aq) + 3H_2O(l)$$

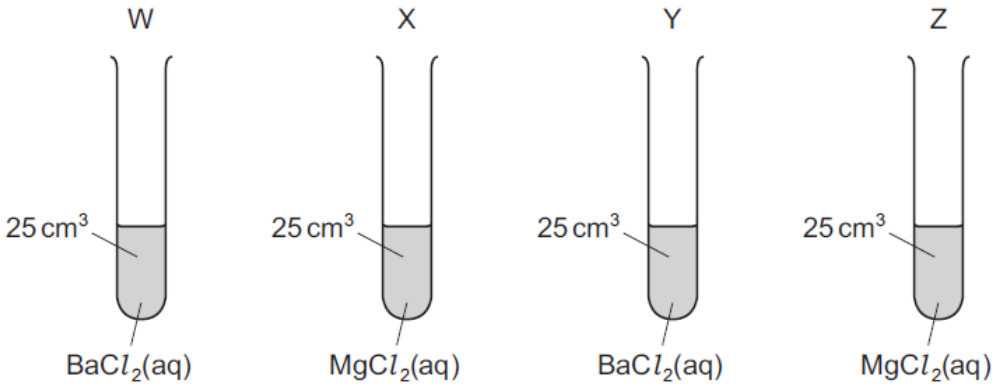
Which row is correct?

	x	$[Na^+](aq)$ after reaction / mol dm^{-3}
A	3	4.0
B	3	less than 4.0
C	6	4.0
D	6	less than 4.0

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3. Nov/2022/Paper_12/No.20

In the diagram, each test-tube W, X, Y and Z contains 25 cm^3 of a 0.1 mol dm^{-3} solution of a salt.



To test-tubes W and X, 25 cm^3 of 0.1 mol dm^{-3} NaOH(aq) is added.

To test-tubes Y and Z, 25 cm^3 of 0.1 mol dm^{-3} $H_2SO_4(aq)$ is added.

In which of test-tubes W and X does the liquid have the higher pH and which of test-tubes Y and Z has the greater mass of precipitate?

	higher pH	greater mass of precipitate
A	W	Y
B	W	Z
C	X	Y
D	X	Z

4. Nov/2022/Paper_12/No.21

What is the oxidation state of the chlorine-containing species that kills bacteria in drinking water?

A –1 **B** +1 **C** +3 **D** +5

5. Nov/2022/Paper_12/No.22

Compound Q is a white crystalline solid which dissolves easily in water.

When concentrated sulfuric acid is added to a dry sample of Q, steamy white fumes are formed.

When these white fumes are passed into aqueous silver nitrate solution, a white precipitate forms.

This precipitate is soluble in dilute ammonia solution.

What is compound Q?

A AgCl **B** NaBr **C** NaCl **D** $PbBr_2$

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6. Nov/2022/Paper_22/No.2(e, f)

(e) (i) An excess of Cl^-(aq) is added to 1 cm^3 of Br_2(aq).

Describe what is observed. Explain your answer.

.....

.....

..... [2]

(ii) SCl_2 has M_r = 103.1 and is a liquid at room temperature. SBr_2 has M_r = 191.9 and is a gas at room temperature.

Explain the difference in the physical state of SCl_2 and SBr_2. Give your answer in terms of intermolecular forces.

.....

.....

.....

..... [2]

(f) Bismuth is a dense metal in the same group as phosphorus.

(i) Draw a labelled diagram to show the bonding in bismuth metal.

[2]

(ii) Bismuth reacts with chlorine to form $BiCl_3$.
$BiCl_3$ is a solid at room temperature. It melts when heated gently.
$BiCl_3$ reacts vigorously with water at room temperature to form an acidic solution.

Suggest the type of bonding and structure shown by $BiCl_3$. Explain your answer.

.....

.....

..... [2]

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Group 17 – 2023 AS Chemistry 9701

1. Nov/2023/Paper_ 9701/11/No.22

In this question, Q represents an atom of chlorine, bromine or iodine.

Which explanation for the variation in volatility down Group 17 is correct?

A Instantaneous dipole–induced dipole forces between molecules become stronger.

B Permanent dipole–permanent dipole forces between molecules become stronger.

C The bond energy of the Q_2 molecules decreases.

D The first ionisation energy $Q(g) \rightarrow Q^+(g) + e^-$ decreases.

2. Nov/2023/Paper_ 9701/11/No.23

Which statement about the halogens or halide ions is correct?

A Bromide ions react to form a white precipitate when added to silver nitrate solution.

B Bromine does **not** oxidise chloride ions when added to sodium chloride solution.

C Fluorine atoms form cations by accepting electrons when they react.

D Chloride ions are stronger reducing agents than iodide ions.

3. Nov/2023/Paper_ 9701/12/No.24

Iodine has a higher melting point than chlorine.

What is the reason for this?

A Iodine has stronger covalent bonds than chlorine.

B Iodine molecules have stronger permanent dipoles than chlorine molecules.

C Iodine is more volatile than chlorine.

D Iodine has stronger instantaneous dipole–induced dipole forces than chlorine.

4. Nov/2023/Paper_ 9701/12/No.25

When concentrated sulfuric acid is added to solid sodium chloride, HCl is formed but **not** Cl_2.

When concentrated sulfuric acid is added to solid sodium iodide, I_2 is formed.

Which statement explains these observations?

A Sulfuric acid is an oxidising agent and chloride ions are more easily oxidised than iodide ions.

B Sulfuric acid is an oxidising agent and iodide ions are more easily oxidised than chloride ions.

C Sulfuric acid is a reducing agent and chloride ions are more easily reduced than iodide ions.

D Sulfuric acid is a reducing agent and iodide ions are more easily reduced than chloride ions.

5. Nov/2023/Paper_ 9701/21/No.3(c)

(c) Fig. 3.1 shows a reaction scheme that involves H_3PO_4 in several reactions.

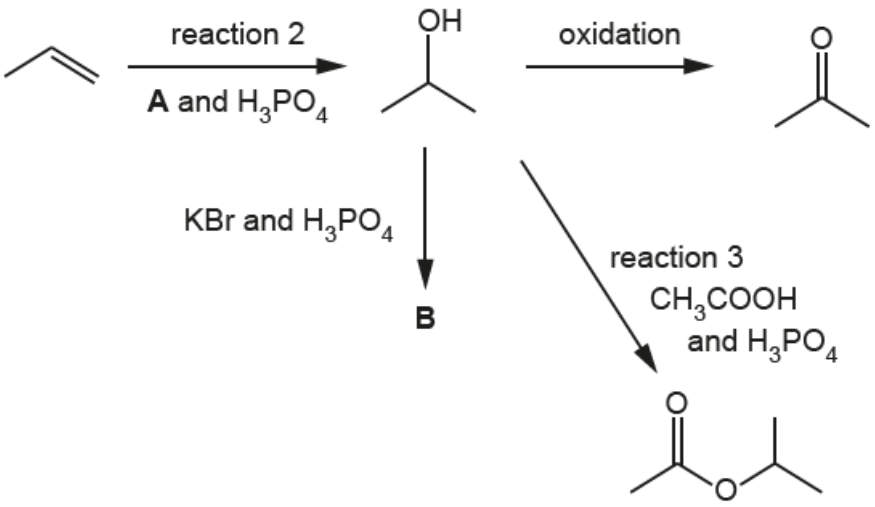


Fig. 3.1

(i) Identify **A**, which reacts with propene in the presence of H_3PO_4 in reaction 2.

..... [1]

(ii) Draw the structure of **B**.

[1]

(iii) Name the type of reaction that occurs in reaction 3.

..... [1]

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(iv) Reaction 3 is monitored using infrared spectroscopy. It is not possible to use the O—H absorption frequency to monitor the reaction.

Use Table 3.2 to identify a suitable bond whose absorption frequency can be used to monitor the progress of reaction 3.

State the change you would see in the infrared spectrum during reaction 3.

bond .....

change in infrared spectrum .....

.....

[2]

Table 3.2

bond	functional groups containing the bond	characteristic infrared absorption range (in wavenumbers) / cm^{-1}
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C–H	alkane	2850–2950

6. June/2023/Paper_9701/11/No.9

Bromine reacts with aqueous sodium hydroxide at 25 °C.

reaction 1 $Br_2(aq) + 2NaOH(aq) \rightarrow NaBr(aq) + NaOBr(aq) + H_2O(l)$

The NaOBr formed is unstable at 25 °C and reacts further.

reaction 2 $3NaOBr(aq) \rightarrow 2NaBr(aq) + NaBrO_3(aq)$

Which reactions are disproportionations?

A both reaction 1 and reaction 2

B neither reaction 1 nor reaction 2

C reaction 1 only

D reaction 2 only

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7. June/2023/Paper_9701/11/No.14

Chlorine dioxide, ClO_2, reacts with aqueous sodium hydroxide to produce water and a mixture of two sodium salts, $NaClO_2$ and $NaClO_3$.

What is the mole ratio of $NaClO_2$ to $NaClO_3$ in the product mixture?

A 1:2 **B** 3:5 **C** 1:1 **D** 5:3

8. June/2023/Paper_9701/11/No.17

The solids sodium chloride and sodium iodide both react with concentrated sulfuric acid at room temperature.

With $NaCl$, the products are $NaHSO_4$ and HCl.

With NaI, the products are $NaHSO_4$, HI, I_2, SO_2, H_2O, S and H_2S.

What is the explanation for this difference in products?

A Chloride ions will displace iodine from the solution.

B Hydrogen chloride is more volatile than hydrogen iodide.

C Iodide ions are better reducing agents than chloride ions.

D Sulfuric acid is able to act as a dehydrating agent with NaI.

9. June/2023/Paper_9701/11/No.22

The boiling points of Br_2, ICl and IBr are given in the table.

	Br_2	ICl	IBr
boiling point / °C	59	97	116

Which row explains:

- why the boiling point of ICl is greater than Br_2
- why the boiling point of IBr is greater than ICl?

	boiling point of ICl is greater than Br_2	boiling point of IBr is greater than ICl
A	ICl has stronger instantaneous dipole-induced dipoles	IBr has stronger instantaneous dipole-induced dipoles
B	ICl has permanent dipoles	IBr has stronger instantaneous dipole-induced dipoles
C	ICl has stronger instantaneous dipole-induced dipoles	IBr has stronger permanent dipoles
D	ICl has permanent dipoles	IBr has stronger permanent dipoles

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10. June/2023/Paper_9701/12/No.22

J dissolves in water to give an aqueous solution K.

K gives a dense white precipitate when aqueous silver nitrate is added.

When heated with aqueous potassium hydroxide, K gives off a gas that turns moist universal indicator paper blue.

What is J?

A ammonium chloride

B ammonium sulfate

C sodium chloride

D sodium hydroxide

11. June/2023/Paper_9701/13/No.17

Which row shows the expected properties of the element astatine when compared to the properties of the element iodine?

	electronegativity of astatine compared to iodine	volatility of astatine compared to iodine
A	less electronegative	higher
B	more electronegative	higher
C	less electronegative	lower
D	more electronegative	lower

12. June/2023/Paper_9701/13/No.24

Which statement about the halogens is correct?

A Iodine cannot behave as an oxidising agent.

B The volatility of the elements increases from chlorine to iodine because of the increase in molecular size down the group.

C When an equimolar mixture of chlorine and hydrogen is exploded, only one product is formed.

D When concentrated sulfuric acid is added to solid sodium bromide, hydrogen sulfide is one of the products.

13. June/2023/Paper_9701/13/No.25

When concentrated sulfuric acid is added to solid sodium bromide, bromine gas is produced, along with a number of other products. However, when concentrated sulfuric acid is added to solid sodium chloride, only hydrogen chloride and sodium hydrogensulfate are produced.

What is the reason for this difference?

A Bromine is less volatile than chlorine.

B Hydrochloric acid is a weak acid.

C Sulfuric acid is **not** an oxidising agent.

D The bromide ion is a stronger reducing agent than the chloride ion.

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14. June/2023/Paper_9701/21/No.3(a _ c)

Chlorine is a very reactive element.

(a) Chlorine reacts with silicon to form silicon(IV) chloride.
Describe the appearance of silicon(IV) chloride at room temperature and pressure. State its structure and bonding.

appearance .....

structure and bonding .....
[2]

(b) Samples of magnesium chloride and phosphorus(V) chloride are added to separate beakers of cold water.

Complete Table 3.1. Ignore temperature changes when considering observations for these reactions.

Table 3.1

	magnesium chloride	phosphorus(V) chloride
appearance at room temperature		
one similarity in observation on addition to cold water		
one difference in observation on addition to cold water		
pH of final solution		

[4]

(c) **(i)** State the reagent and conditions required for the formation of sodium chlorate(V) from $Cl_2(g)$.

..... [1]

(ii) Explain why the reaction in **(c)(i)** is described as a disproportionation reaction.
Your answer should refer to relevant species and their oxidation numbers.

.....

..... [1]

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15. June/2023/Paper_9701/22/No.2

Chlorine is a reactive element. It forms many compounds.

(a) **(i)** Complete Table 2.1 to show the maximum oxidation number of the elements Na to P in their chlorides.

Table 2.1

element	Na	Mg	Al	Si	P
maximum oxidation number					

[1]

(ii) State what determines the maximum oxidation number of elements in Period 3.

.....

..... [1]

(b) An excess of cold water is added to the chloride of silicon.

(i) Write an equation for the reaction between an excess of cold water and the chloride of silicon.

..... [1]

(ii) Suggest the pH of the solution produced in **(b)(i)**.

..... [1]

(c) An excess of cold water is added to the chloride of phosphorus.

(i) Write an equation for the reaction between an excess of cold water and the chloride of phosphorus.

..... [1]

(ii) Suggest the pH of the solution produced in **(c)(i)**.

..... [1]

(d) **(i)** Write an equation for the reaction of chlorine with water.

..... [1]

(ii) Write an equation for the reaction of chlorine with hot NaOH(aq).

..... [1]

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(e) Bleach is used as a cleaning product to kill bacteria. It is made by adding compounds like sodium chlorate(I), NaC*l*O, to water.

(i) Identify the formula of the ion present in bleach that kills bacteria.

..... [1]

(ii) Sodium chlorate(I), NaC*l*O, reacts with hydrogen peroxide to produce sodium chloride, water and oxygen gas.

Construct an equation for this reaction.

..... [1]

(iii) A sample of bleach **W** contains an unknown concentration of sodium chlorate(I).

10.0 cm^3 of **W** is diluted with distilled water to make a total volume of 100 cm^3 of bleach solution. 25.0 cm^3 of this diluted bleach solution is added to an excess of hydrogen peroxide and the volume of gas produced measured under room conditions. The experiment is repeated and on average 25.0 cm^3 of diluted bleach solution produces 42.0 cm^3 of gas.

Calculate the concentration, in g dm^{-3}, of sodium chlorate(I) in **W**.

concentration of NaC*l*O in **W** = ... g dm^{-3} [3]

[Total: 13]

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16. March/2023/Paper_9701/12/No.18

Powder P is a mixture containing two of AgC*l*, AgBr or AgI.

P is shaken with dilute aqueous ammonia. A yellow solid, Q, remains.

The mixture is filtered and Q is washed and dried. The filtrate is collected and treated with aqueous nitric acid to produce a white precipitate, R, which is filtered off, washed and dried.

Q and R are warmed separately with concentrated sulfuric acid, H_2SO_4.

Which observations are made?

	Q + concentrated H_2SO_4	R + concentrated H_2SO_4
A	violet fumes	orange fumes
B	violet fumes	steamy fumes
C	steamy fumes	violet fumes
D	orange fumes	steamy fumes

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