



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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0620/41

October/November 2022

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **16** pages. Any blank pages are indicated.

1 The names of the elements of Period 2 of the Periodic Table are shown.

lithium beryllium boron carbon nitrogen oxygen fluorine neon

Answer the following questions about these elements.

Each element may be used once, more than once or not at all.

Identify the element which:

(a) is a product of photosynthesis

..... [1]

(b) has an oxide found in clean, dry air

..... [1]

(c) forms a basic oxide with the formula X_2O

..... [1]

(d) is a main component of fertilisers used to improve crop growth

..... [1]

(e) has the highest rate of diffusion at room temperature

..... [1]

(f) produces a red flame in a flame test

..... [1]

(g) has only 5 electrons in each of its atoms

..... [1]

(h) has an oxide responsible for acid rain.

..... [1]

[Total: 8]

2 Potassium is a Group I element.

(a) Name and describe the bonding in potassium.

name

description

.....

.....

.....

[4]

(b) Potassium combines with sulfur to form an ionic compound, potassium sulfide, K_2S .

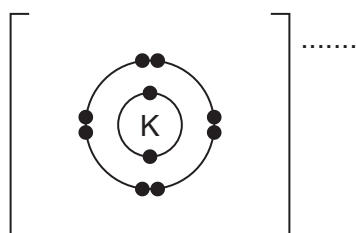
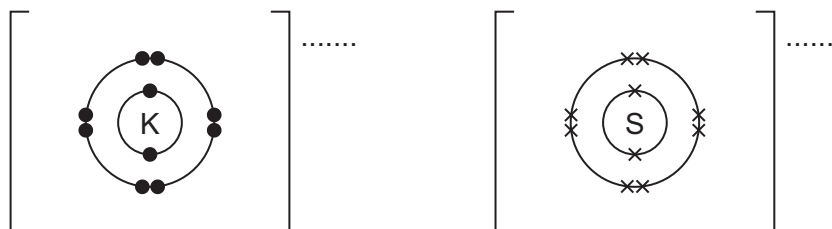
(i) Give **two** physical properties of ionic compounds.

1

2

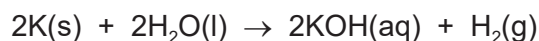
[2]

(ii) Complete the dot-and-cross diagram to show the electron arrangement and charges of the ions in potassium sulfide.



[3]

- (c) When potassium is added to water, it reacts vigorously and a coloured flame is seen. The equation for the reaction is shown.



- (i) State the colour of the flame seen.

..... [1]

- (ii) The solution formed is potassium hydroxide, a strong alkali.

State the formula of the ion responsible for alkalinity in a solution.

..... [1]

- (iii) State the colour of litmus in a strong alkali.

..... [1]

- (iv) Calculate the volume, in cm^3 , of hydrogen gas formed when 2.34 g of potassium is added to excess water at room temperature and pressure.

Use the following steps.

- Calculate the number of moles of potassium added.

= mol

- Determine the number of moles of hydrogen gas formed.

= mol

- Calculate the volume of hydrogen gas formed.

volume = ... cm^3
[3]

(d) Aqueous potassium hydroxide reacts with a dilute acid to produce aqueous potassium chloride, KCl(aq) , which is a salt.

(i) Name the dilute acid used.

..... [1]

(ii) State the type of reaction taking place.

..... [1]

(iii) Name the experimental technique used when salts are made by reacting a dilute acid with an aqueous alkali.

..... [1]

(e) When aqueous silver nitrate, $\text{AgNO}_3\text{(aq)}$, is added to aqueous potassium chloride, a precipitate is formed.

(i) State the colour of the precipitate formed.

..... [1]

(ii) Name the precipitate formed.

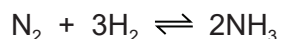
..... [1]

(iii) Write the ionic equation for the reaction. Include state symbols.

..... [3]

[Total: 23]

- 3 Ammonia is made in an industrial process starting with nitrogen. The equation for the reaction is shown.



- (a) Name the industrial process used to make ammonia.

..... [1]

- (b) State the raw material from which nitrogen is obtained.

..... [1]

- (c) State what is meant by the symbol $\rightleftharpoons$.

..... [1]

- (d) State the temperature and pressure used in this industrial process.

temperature = ... °C

pressure = ... atm
[2]

- (e) Name the catalyst used in this industrial process.

..... [1]

- (f) The forward reaction is exothermic.

State the effect, if any, on the position of the equilibrium when the following changes are made.
Explain your answers.

temperature is reduced

.....
.....

pressure is reduced

.....
.....

[4]

- (g) Explain, in terms of particles, what happens to the rate of reaction when the temperature is reduced.

.....

.....

.....

.....

..... [3]

- (h) Give the formula of the compound formed when sulfuric acid reacts with ammonia.

..... [1]

[Total: 14]

4 A student prepares calcium nitrate, $\text{Ca}(\text{NO}_3)_2$, by adding calcium carbonate to dilute nitric acid.

(a) Write the chemical equation for this reaction.

..... [2]

(b) Describe **two** observations during this reaction.

1

2 [2]

(c) The student continues to add calcium carbonate until it is in excess. The student then removes the excess calcium carbonate by filtration and collects the aqueous calcium nitrate.

State the general term given to a solution collected from filtration.

..... [1]

(d) The student gently heats the aqueous calcium nitrate until the solution is saturated.

(i) Suggest what is meant by the term *saturated solution*.

.....
..... [2]

(ii) Describe how crystals are produced from a hot saturated solution.

..... [1]

- (e) Calcium nitrate crystals are hydrated and have the formula $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$ where x is a whole number of molecules of water.

The student heats the crystals to remove the molecules of water.



- (i) State the term used to describe the calcium nitrate after the molecules of water have been removed.

..... [1]

- (ii) The student heats a sample of $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$ and forms 2.46 g of $\text{Ca}(\text{NO}_3)_2$ and 0.0600 moles of H_2O .

Determine the value of x . Use the following steps.

- Calculate the M_r of $\text{Ca}(\text{NO}_3)_2$.

$M_r =$

- Determine the number of moles of $\text{Ca}(\text{NO}_3)_2$ formed.

moles of $\text{Ca}(\text{NO}_3)_2$ formed = ...

- Determine the value of x in $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$.

$x =$
[3]

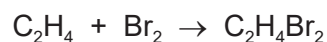
- (f) Nitrates decompose on heating.

Write the chemical equation for the reaction when solid sodium nitrate is heated.

..... [2]

[Total: 14]

- 5 Ethene is an alkene which reacts with bromine as shown in the equation.



- (a) Write the general formula of alkenes.

..... [1]

- (b) Describe the colour change seen when ethene is bubbled through aqueous bromine.

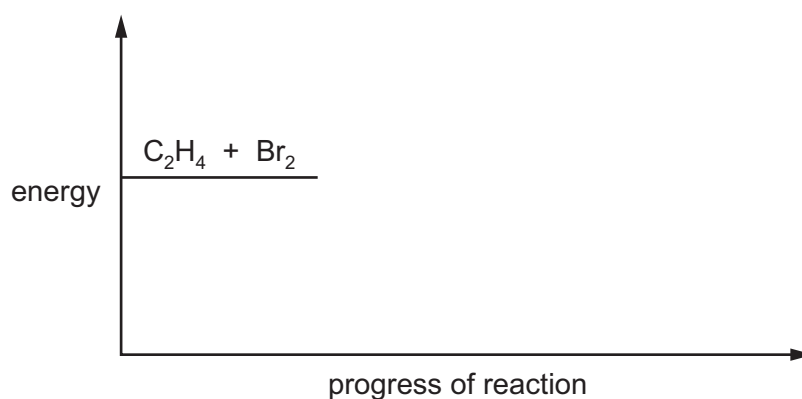
from to [1]

- (c) In this reaction only one product is formed from two reactants.

Name this type of organic reaction.

..... [1]

- (d) Part of the energy profile diagram of this reaction is shown.



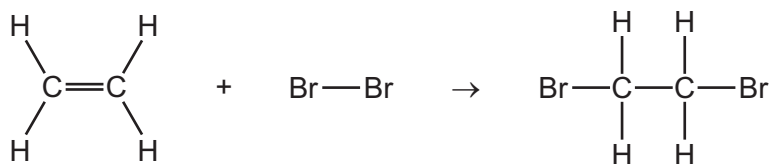
- (i) The reaction is exothermic.

Complete the energy profile diagram for this reaction.
Include:

- the position of the products
- an arrow to show the activation energy, labelled as A
- an arrow to show the energy change for the reaction.

[3]

(ii) The chemical equation for the reaction can be represented as shown.



Some bond energies are given.

bond	bond energy /kJ mol
C–H	410
C=C	610
Br–Br	190
C–C	350
C–Br	290

Use the bond energies in the table to calculate the energy change in this reaction.

Use the following steps.

- Calculate the energy needed to break bonds.

energy = ... kJ

- Calculate the energy released in making bonds.

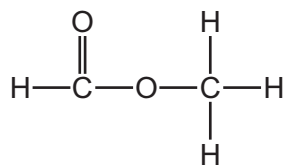
energy = ... kJ

- Determine the energy change in this reaction.

energy change in this reaction = ... kJ/mol
[3]

[Total: 9]

6 Ester Y has the structure shown.



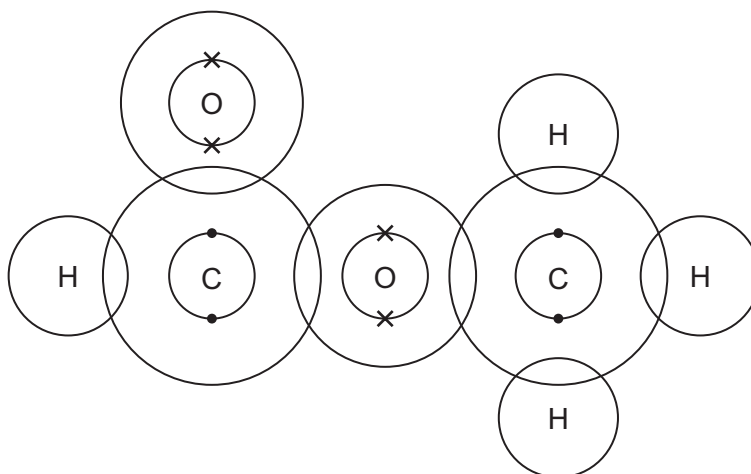
(a) (i) Name ester Y.

..... [1]

(ii) Deduce the empirical formula of ester Y.

..... [1]

(b) Complete the dot-and-cross diagram to show the arrangement of electrons in a molecule of ester Y.



[3]

(c) Ester **Y** can be made by reacting two organic compounds together.

Name the compounds and draw their structures.

Show all of the atoms and all of the bonds.

name

structure

name

structure

[4]

(d) (i) Describe what is meant by the term *structural isomer*.

.....

..... [2]

(ii) Name a carboxylic acid which is a structural isomer of ester **Y**.

..... [1]

[Total: 12]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
		1Hhydrogen1															
		Key atomic number atomic symbol name relative atomic mass															
3Li lithium 7	4Be beryllium 9											5B boron 11	6C carbon 12	7N nitrogen 14	8O oxygen 16	9F fluorine 19	10Ne neon 20
11Na sodium 23	12Mg magnesium 24											13Al aluminium 27	14Si silicon 28	15P phosphorus 31	16S sulfur 32	17Cl chlorine 35.5	18Ar argon 40
19K potassium 39	20Ca calcium 40	21Sc scandium 45	22Ti titanium 48	23V vanadium 51	24Cr chromium 52	25Mn manganese 55	26Fe iron 56	27Co cobalt 59	28Ni nickel 59	29Cu copper 64	30Zn zinc 65	31Ga gallium 70	32Ge germanium 73	33As arsenic 75	34Se selenium 79	35Br bromine 80	36Kr krypton 84
37Rb rubidium 85	38Sr strontium 88	39Y yttrium 89	40Zr zirconium 91	41Nb niobium 93	42Mo molybdenum 96	43Tc technetium —	44Ru ruthenium 101	45Rh rhodium 103	46Pd palladium 106	47Ag silver 108	48Cd cadmium 112	49In indium 115	50Sn tin 119	51Sb antimony 122	52Te tellurium 128	53I iodine 127	54Xe xenon 131
55Cs caesium 133	56Ba barium 137	57–71 lanthanoids		72Hf hafnium 178	73Ta tantalum 181	74W tungsten 184	75Re rhenium 186	76Os osmium 190	77Ir iridium 192	79Au gold 197	80Hg mercury 201	81Tl thallium 204	82Pb lead 207	83Bi bismuth 209	84Po polonium —	85At astatine —	86Rn radon —
87Fr francium —	88Ra radium —	89–103 actinoids		104Rf rutherfordium —	105Db dubnium —	106Sg seaborgium —	107Bh bohrium —	108Hs hassium —	109Mt meitnerium —	110Ds darmstadtium —	111Rg roentgenium —	112Cn copernicium —	114Fl flerovium —	116Lv livermorium —			
lanthanoids																	
57La lanthanum 139	58Ce cerium 140	59Pr praseodymium 141	60Nd neodymium 144	61Pm promethium —	62Sm samarium 150	63Eu europium 152	64Gd gadolinium 157	65Tb terbium 159	66Dy dysprosium 163	67Ho holmium 165	68Er erbium 167	69Tm thulium 169	70Yb ytterbium 173	71Lu lutetium 175			
actinoids																	
89Ac actinium —	90Th thorium 232	91Pa protactinium 231	92U uranium 238	93Np neptunium —	94Pu plutonium —	95Am americum —	96Cm curium —	97Bk berkelium —	98Cf californium —	99Es einsteinium —	100Fm fermium —	101Md mendelevium —	102No nobelium —	103Lr lawrencium —			

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).



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0620/42

October/November 2022

1 hour 15 minutes

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This document has **16** pages. Any blank pages are indicated.

- 1 Diamond and graphite are different solid forms of carbon. The carbon atoms in diamond and graphite are arranged in different ways.

(a) State the number of covalent bonds each carbon atom has in diamond.

..... [1]

(b) State the term used to describe the structure of diamond.

..... [1]

(c) Name an oxide that has a similar structure to diamond.

..... [1]

(d) Describe the arrangement of atoms in graphite.

.....

..... [2]

(e) Explain how graphite conducts electricity.

..... [1]

(f) Buckminsterfullerene is a simple molecular form of carbon.

The relative molecular mass of Buckminsterfullerene is 720.

Determine the number of carbon atoms in one molecule of Buckminsterfullerene.

..... [1]

(g) All forms of carbon burn to produce carbon dioxide.

Name the substance used to test for carbon dioxide.

..... [1]

[Total: 8]

2 Sodium is a reactive metal.

(a) Suggest why sodium is stored under oil.

..... [1]

(b) Sodium burns in air to form sodium oxide, Na_2O .

(i) State the term given to a reaction in which a substance burns.

..... [1]

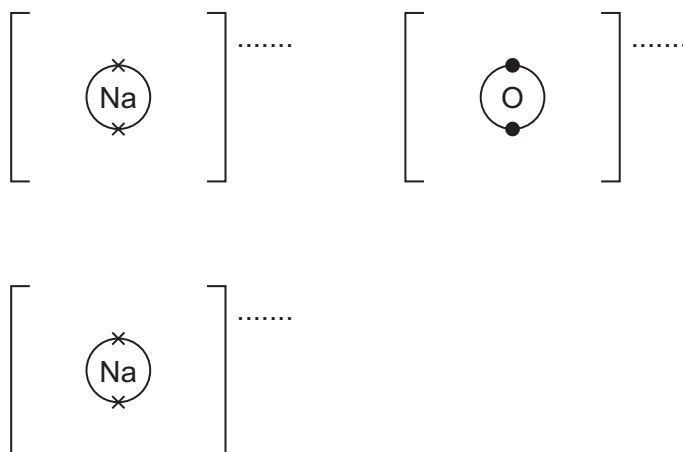
(ii) State the colour of the flame seen when sodium burns.

..... [1]

(iii) Write a chemical equation for the reaction which takes place when sodium burns in air to form sodium oxide.

..... [2]

(iv) Complete the dot-and-cross diagram to show the electron arrangement and charges of the ions in sodium oxide.



[3]

(c) Sodium reacts vigorously with water to form aqueous sodium hydroxide, NaOH, which is a strong base.

(i) Explain in terms of proton transfer what is meant by a base.

..... [1]

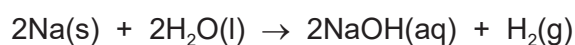
(ii) State a pH number that indicates the presence of a strong alkali.

..... [1]

(iii) State the colour of methyl orange in aqueous sodium hydroxide.

..... [1]

(iv) The equation for the reaction is shown.



Calculate the concentration of NaOH(aq) formed, in g/dm³, when 0.345 g of sodium is added to 50.0 cm³ of distilled water. Assume there is no change in volume.

Use the following steps.

- Calculate the number of moles of Na added.

= mol

- Determine the number of moles of NaOH formed.

= mol

- Calculate the concentration of NaOH in mol/dm³.

concentration of NaOH = ... mol/dm³

- Determine the M_r of NaOH and calculate the concentration of NaOH in g/dm³.

concentration of NaOH = ... g/dm³
[5]

(d) When NaOH(aq) is added to aqueous iron(III) chloride, $\text{FeCl}_3\text{(aq)}$, a solid product is formed.

(i) Name the type of reaction where a solid is formed from two solutions.

..... [1]

(ii) State the colour of this solid product.

..... [1]

(iii) Name this solid product.

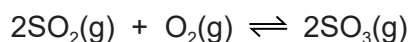
..... [1]

(iv) Write the ionic equation for the reaction. Include state symbols.

..... [3]

[Total: 22]

- 3 Sulfuric acid is manufactured by an industrial process. Sulfur is obtained from sulfur-containing metal ores.
The sulfur in the metal ore is converted to sulfur dioxide which is then oxidised to sulfur trioxide as shown.



- (a) Name a metal ore which contains sulfur.

..... [1]

- (b) Describe the process which converts metal ores to sulfur dioxide.

..... [1]

- (c) Name the industrial process used to manufacture sulfuric acid.

..... [1]

- (d) The reaction that produces sulfur trioxide is an equilibrium. The forward reaction is exothermic.

- (i) State the temperature and pressure used to make sulfur trioxide.

temperature = ... °C

pressure = ... atm
[2]

- (ii) Name the catalyst used.

..... [1]

- (iii) Describe **two** features of an equilibrium.

1

2

[2]

- (iv) State the effect, if any, on the position of equilibrium when the following changes are made.

Explain your answers.

temperature is increased

.....

pressure is increased

.....

[4]

- (v) Explain, in terms of particles, what happens to the rate of reaction when the temperature is increased.

.....

.....

.....

.....

..... [3]

- (e) Name the compound formed when sulfuric acid reacts with ammonia.

..... [1]

[Total: 16]

- 4 A student prepares magnesium sulfate crystals, MgSO_4 , by adding excess magnesium to dilute sulfuric acid.

(a) Write the chemical equation for this reaction.

..... [1]

(b) Describe **two** observations which show the reaction has finished.

1

2 [2]

(c) The excess magnesium is removed by filtration.

State the general name given to a solid separated from a solution by filtration.

..... [1]

(d) The aqueous magnesium sulfate is heated until crystals begin to appear.

(i) Suggest the name for a solution in which no more solute can dissolve.

..... [1]

(ii) Suggest why more crystals of magnesium sulfate appear on cooling.

..... [1]

(e) Magnesium sulfate crystals have the formula, $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$, where x is a whole number of molecules of water.

The student heats the crystals to remove the molecules of water.



(i) Name the term given to crystals containing molecules of water.

..... [1]

- (ii) The student heats a sample of $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ and finds it has lost 0.140 moles of H_2O and has 2.40 g of MgSO_4 remaining.

Determine the value of x . Use the following steps.

- Calculate the M_r of MgSO_4 .

$$M_r = \dots\dots\dots$$

- Determine the number of moles of MgSO_4 formed.

$$\text{moles of } \text{MgSO}_4 \text{ formed} = \dots\dots\dots$$

- Determine the value of x in $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$.

$$x = \dots\dots\dots [3]$$

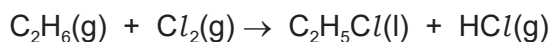
- (f) If the student uses dilute nitric acid instead of dilute sulfuric acid, the salt formed is magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$.

Write the chemical equation for the reaction when solid magnesium nitrate is heated.

..... [2]

[Total: 12]

- 5 Ethane is an alkane which undergoes a photochemical reaction with chlorine as shown.



- (a) Write the general formula of alkanes.

..... [1]

- (b) State why this reaction is described as a photochemical reaction.

..... [1]

- (c) In this reaction, an atom of hydrogen is replaced with a chlorine atom.

State the name of this type of organic reaction.

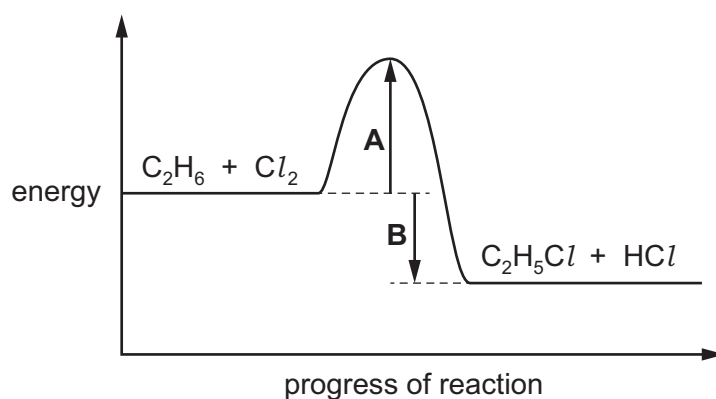
..... [1]

- (d) In this reaction, one of the products is chloroethane.

Name the other product.

..... [1]

- (e) The energy profile diagram of this reaction is shown.



- (i) Name the energy change labelled **A**.

..... [1]

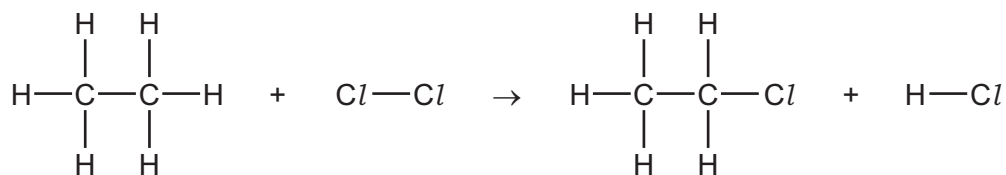
- (ii) Name the energy change labelled **B**.

..... [1]

- (iii) State how the energy profile diagram shows this is an exothermic reaction.

..... [1]

(f) The equation for the reaction can be represented as shown.



Some bond energies are given.

bond	bond energy / kJ mol
C-H	410
C-C	350
Cl-Cl	240
C-Cl	340
H-Cl	430

Use the bond energies in the table to calculate the energy change in this reaction.

Use the following steps.

- Calculate the energy needed to break bonds.

energy = ... kJ

- Calculate the energy released in making bonds.

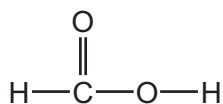
energy = ... kJ

- Determine the energy change in this reaction.

energy change in this reaction = ... kJ/mol
[3]

[Total: 10]

- 6 A carboxylic acid **Y** has the structure shown.



- (a) State the general formula of carboxylic acids.

..... [1]

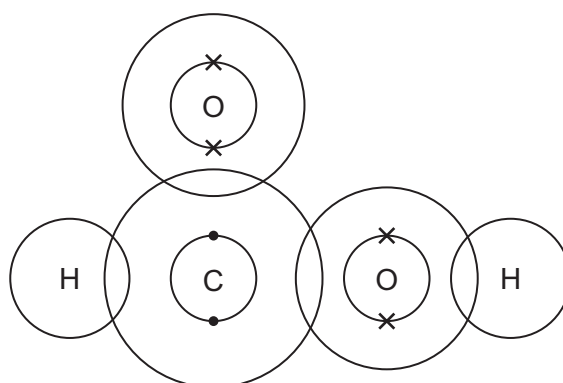
- (b) Name carboxylic acid **Y**.

..... [1]

- (c) Write the molecular formula of carboxylic acid **Y**.

..... [1]

- (d) Complete the dot-and-cross diagram to show the arrangement of electrons in a molecule of carboxylic acid **Y**.



[3]

(e) Carboxylic acid **Y** will react with propan-1-ol, $\text{C}_3\text{H}_7\text{OH}$, to form ester **Z** and one other product.

(i) Name and draw the structure of ester **Z**.

Show all of the atoms and all of the bonds.

name

structure

[3]

(ii) Name the other product formed when carboxylic acid **Y** reacts with propan-1-ol.

..... [1]

(iii) Name:

- an ester which is a structural isomer of ester **Z**

.....

- a carboxylic acid which is a structural isomer of ester **Z**.

.....

[2]

[Total: 12]

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The Periodic Table of Elements

Group																									
I	II											III	IV	V	VI	VII	VIII								
		1 H hydrogen 1																							
		Key atomic number atomic symbol name relative atomic mass																							
3 Li lithium 7	4 Be beryllium 9													5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20						
11 Na sodium 23	12 Mg magnesium 24													13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40						
19 K potassium 39	20 Ca calcium 40													31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84						
37 Rb rubidium 85	38 Sr strontium 88													49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131						
55 Cs caesium 133	56 Ba barium 137													81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —	85 At astatine —	86 Rn radon —						
87 Fr francium —	88 Ra radium —													112 Cn copernicium —	111 Rg roentgenium —	110 Ds darmstadtium —	109 Mt meitnerium —	108 Hs hassium —	107 Bh bohrium —	106 Sg seaborgium —	105 Db dubnium —	104 Rf rutherfordium —	89–103 actinoids	116 Lv livermorium —	

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium —	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
	89 Ac actinium —	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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0620/43

October/November 2022

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **16** pages. Any blank pages are indicated.

- 1 Atoms and ions are made from small particles called electrons, neutrons and protons.

(a) Complete the table.

particle	relative charge	relative mass
electron	-1	$\frac{1}{1840}$
neutron		
proton		

[2]

(b) Information about atoms and ions, **A**, **B** and **C**, is shown in the table.

Complete the table.

atom or ion	number of electrons	number of neutrons	number of protons	symbol
A	18		20	${}^{42}_{20}\text{Ca}^{2+}$
B		18		${}^{35}_{17}\text{Cl}$
C	18	16	16	

[6]

[Total: 8]

- 2 The table shows the melting points, boiling points and electrical conductivities of six substances, **D**, **E**, **F**, **G**, **H** and **I**.

substance	melting point /°C	boiling point /°C	conducts electricity when solid	conducts electricity when liquid
D	1083	2567	yes	yes
E	–117	79	no	no
F	3550	4827	no	no
G	119	445	no	no
H	–210	–196	no	no
I	801	1413	no	yes

- (a) Identify the substance, **D**, **E**, **F**, **G**, **H** or **I**, which is:

(i) a liquid at 25°C [1]

(ii) a gas at 25°C [1]

(iii) a solid consisting of simple molecules at 25°C. [1]

- (b) Identify the substance, **D**, **E**, **F**, **G**, **H** or **I**, which is a metal. Give a reason for your choice.

substance

reason [2]

- (c) Identify the substance, **D**, **E**, **F**, **G**, **H** or **I**, which has a macromolecular structure. Give **two** reasons for your choice.

substance

reason 1

reason 2 [3]

- (d) Identify the substance, **D**, **E**, **F**, **G**, **H** or **I**, which is an ionic solid. Give a reason for your choice.

substance

reason

..... [2]

[Total: 10]

3 Aluminium is extracted from its ore by electrolysis.

(a) Name the ore of aluminium which consists mainly of aluminium oxide.

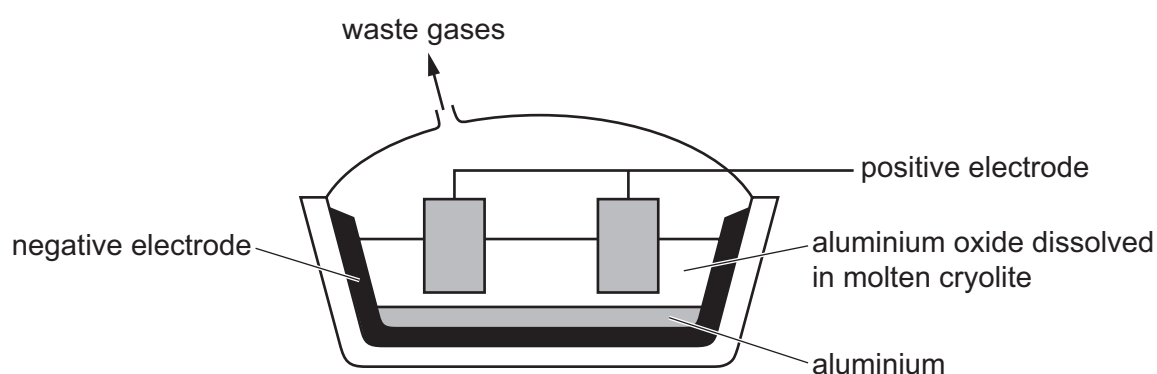
..... [1]

(b) State what is meant by the term *electrolysis*.

.....

..... [2]

(c) Electrolysis is carried out on aluminium oxide dissolved in molten cryolite.



(i) Give **two** reasons why the electrolysis is carried out on aluminium oxide dissolved in molten cryolite instead of electrolysis molten aluminium oxide only.

1

2

[2]

(ii) Write the ionic half-equation for the reaction occurring at the negative electrode.

..... [2]

(iii) The positive electrodes are made of carbon.

Explain why the positive carbon electrodes are replaced regularly.

.....

..... [2]

- (d) Aluminium is more reactive than copper.

When aluminium is added to aqueous copper(II) sulfate, no immediate reaction is seen.

Explain why.

..... [1]

- (e) Aluminium reacts with oxygen to form an amphoteric oxide.

- (i) State what is meant by the term *amphoteric*.

.....

..... [1]

- (ii) The reaction between aluminium oxide and aqueous sodium hydroxide forms a salt containing the negative ion AlO_2^- . The only other product is water.

Write a chemical equation for the reaction between aluminium oxide and aqueous sodium hydroxide.

..... [2]

- (f) Gallium is in the same group as aluminium and forms similar compounds.

Predict the formulae of:

gallium(III) chloride

gallium(III) sulfate.

[2]

[Total: 15]

4 This question is about compounds of phosphorus.

- (a) Gaseous phosphorus(V) chloride decomposes into gaseous phosphorus(III) chloride and gaseous chlorine.

When the three gases are present in a closed container the system reaches equilibrium.



- (i) Complete the table using only the words *increases*, *decreases* or *no change*.

	effect on the rate of the forward reaction	effect on the equilibrium yield ($\text{PCl}_3(\text{g})$ and $\text{Cl}_2(\text{g})$)
increasing the temperature		increases
decreasing the pressure		
adding a catalyst		no change

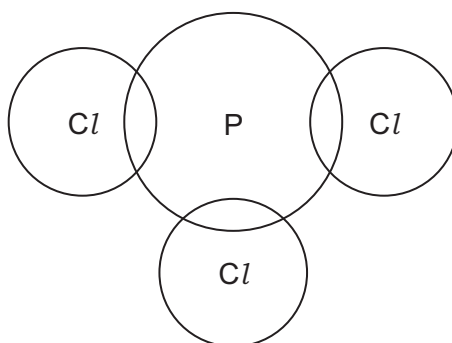
[4]

- (ii) The table shows that when the temperature increases, the equilibrium yields of $\text{PCl}_3(\text{g})$ and $\text{Cl}_2(\text{g})$ increase.

State what conclusion can be made from this.

..... [1]

- (b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of phosphorus(III) chloride, PCl_3 . Show outer shell electrons only.



[2]

- (c) Phosphorus oxychloride has the formula POCl_3 .

Phosphorus oxychloride is the only product of the reaction between phosphorus(V) chloride, PCl_5 , and phosphorus(V) oxide, P_4O_{10} .

Write a chemical equation for the reaction between phosphorus(V) chloride and phosphorus(V) oxide.

..... [2]

- (d) Compound **X** has the following composition by mass.

H, 3.66%; P, 37.80%; O, 58.54%

Calculate the empirical formula of compound **X**.

empirical formula = ... [2]

- (e) Compound **Y** has the empirical formula H_3PO_4 and a relative molecular mass of 98.

Deduce the molecular formula of compound **Y**.

molecular formula = ... [1]

[Total: 12]

5 This question is about sulfuric acid, H_2SO_4 , and salts that can be made from sulfuric acid.

(a) Sulfuric acid is manufactured by the Contact process.

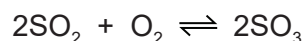
stage 1 Molten sulfur burns in air to produce sulfur dioxide.

stage 2 Sulfur dioxide reacts with oxygen to form sulfur trioxide, SO_3 .

stage 3 Sulfur trioxide reacts with concentrated sulfuric acid to form oleum, $\text{H}_2\text{S}_2\text{O}_7$.

stage 4 Oleum is converted into sulfuric acid.

(i) The equation for the reaction in **stage 2** is shown.



State the temperature and pressure used in **stage 2**.

Name the catalyst used in **stage 2**.

temperature °C

pressure atm

catalyst [3]

(ii) Write the chemical equation for the reaction in **stage 3**.

..... [1]

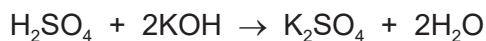
(iii) Name the substance that reacts with oleum in **stage 4**.

..... [1]

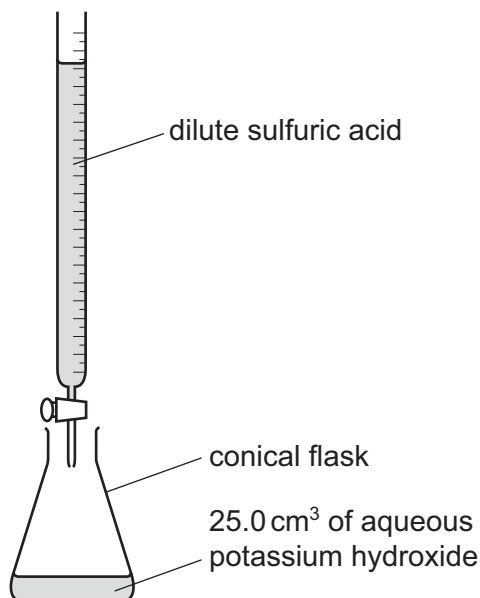
(b) Name the black solid that is produced when concentrated sulfuric acid is added to sugar, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$.

..... [1]

- (c) Dilute sulfuric acid and aqueous potassium hydroxide are used to make aqueous potassium sulfate.



The method includes use of the following apparatus.



- (i) Calculate the volume of 0.0625 mol/dm³ dilute sulfuric acid, H_2SO_4 , that completely reacts with 25.0 cm³ of 0.100 mol/dm³ potassium hydroxide, KOH , to produce aqueous potassium sulfate.

Use the following steps.

- Calculate the number of moles of KOH in 25.0 cm³ of 0.100 mol/dm³ KOH .

= mol

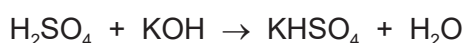
- Deduce the number of moles of H_2SO_4 that react with KOH .

= mol

- Calculate the volume of H_2SO_4 required.

volume = ... cm^3
[3]

- (ii) The experiment is repeated using the same volume and concentration of potassium hydroxide and the same concentration of dilute sulfuric acid. In this second experiment, the product is aqueous potassium hydrogensulfate, KHSO_4 .



Use your answer to (c)(i) and the equation to deduce the volume of H_2SO_4 required.

volume = ... cm^3 [1]

- (d) Aqueous potassium hydrogensulfate, $\text{KHSO}_4(\text{aq})$, contains the ions $\text{K}^+(\text{aq})$, $\text{H}^+(\text{aq})$ and $\text{SO}_4^{2-}(\text{aq})$.

Describe the observations in the following tests.

- (i) A flame test is carried out on aqueous potassium hydrogensulfate.

..... [1]

- (ii) Solid copper(II) carbonate is added to aqueous potassium hydrogensulfate.

.....
..... [2]

- (iii) An acidic solution containing aqueous barium ions, $\text{Ba}^{2+}(\text{aq})$, is added to aqueous potassium hydrogensulfate.

..... [1]

- (e) Write the ionic equation for the reaction in (d)(iii).

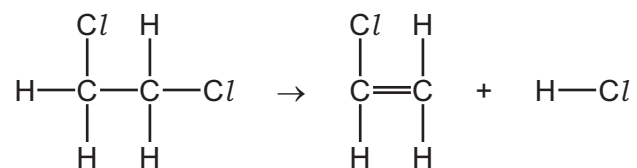
Include state symbols.

..... [3]

[Total: 17]

- 6 (a) Chloroethene ($\text{CH}_2=\text{CHCl}$) can be manufactured from 1,2-dichloroethane ($\text{CH}_2\text{ClCH}_2\text{Cl}$).

The equation can be represented as shown.



- (i) Some bond energies are given.

bond	bond energy in kJ/mol
C—C	350
C=C	610
C—Cl	340
C—H	410
H—Cl	430

Use the bond energies in the table to calculate the energy change, in kJ/mol, of the reaction.

Use the following steps.

- Calculate the energy needed to break bonds.

energy = ... kJ

- Calculate the energy released when bonds form.

energy = ... kJ

- Calculate the energy change of the reaction.

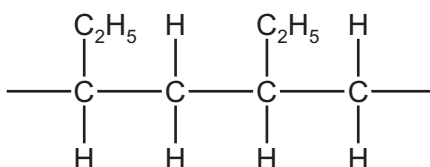
energy change of the reaction = ... kJ/mol
[3]

- (ii) Deduce whether the energy change for this reaction is exothermic or endothermic.

Give a reason for your answer.

.....
..... [1]

- (b) Part of a synthetic polymer is shown.



- (i) State the number of monomer units that are needed to make the part of the polymer shown.

..... [1]

- (ii) Name and draw the structure of the monomer used to make this polymer. Show all of the atoms and all of the bonds.

name

structure

[3]

- (iii) State the empirical formula of the polymer.

..... [1]

(c) Proteins are natural polymers.

Proteins are broken down into amino acids. The process is similar to how complex carbohydrates are broken down to give simple sugars.

(i) Name the type of reaction in which proteins are broken down into amino acids.

..... [1]

(ii) Name **two** types of substance that are used to break down proteins into amino acids.

1

2

[2]

(iii) Amino acids are colourless.

A sample containing a mixture of amino acids is separated. Each amino acid is detected and identified.

- Name the process used to separate the amino acids.

.....

- Name the type of substance used to detect the amino acids.

.....

- Give the symbol of the value used to determine the identity of each amino acid after separation and detection.

.....

[3]

(d) Proteins are natural polymers. Proteins contain amide linkages.

Synthetic polyamides also contain amide linkages.

(i) Name a synthetic polyamide.

..... [1]

(ii) Identify the **two** functional groups present in the monomers used to produce synthetic polyamides.

1

2

[2]

[Total: 18]

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The Periodic Table of Elements

Group																																						
I	II											III	IV	V	VI	VII	VIII																					
		1 H hydrogen 1																																				
		2 He helium 4																																				
3	Li lithium 7	4	Be beryllium 9	atomic number atomic symbol name relative atomic mass										5	B boron 11	6	C carbon 12	7	N nitrogen 14	8	O oxygen 16	9	F fluorine 19	10	Ne neon 20													
11	Na sodium 23	12	Mg magnesium 24											13	Al aluminium 27	14	Si silicon 28	15	P phosphorus 31	16	S sulfur 32	17	Cl chlorine 35.5	18	Ar argon 40													
19	K potassium 39	20	Ca calcium 40	21	Sc scandium 45	22	Ti titanium 48	23	V vanadium 51	24	Cr chromium 52	25	Mn manganese 55	26	Fe iron 56	27	Co cobalt 59	28	Ni nickel 59	29	Cu copper 64	30	Zn zinc 65	31	Ga gallium 70	32	Ge germanium 73	33	As arsenic 75	34	Se selenium 79	35	Br bromine 80	36	Kr krypton 84			
37	Rb rubidium 85	38	Sr strontium 88	39	Y yttrium 89	40	Zr zirconium 91	41	Nb niobium 93	42	Mo molybdenum 96	43	Tc technetium —	44	Ru ruthenium 101	45	Rh rhodium 103	46	Pd palladium 106	47	Ag silver 108	48	Cd cadmium 112	49	In indium 115	50	Sn tin 119	51	Sb antimony 122	52	Te tellurium 128	53	I iodine 127	54	Xe xenon 131			
55	Cs caesium 133	56	Ba barium 137	lanthanoids				71	72	Hf hafnium 178	73	Ta tantalum 181	74	W tungsten 184	75	Re rhenium 186	76	Os osmium 190	77	Ir iridium 192	78	Pt platinum 195	79	Au gold 197	80	Hg mercury 201	81	Tl thallium 204	82	Pb lead 207	83	Bi bismuth 209	84	Po polonium —	85	At astatine —	86	Rn radon —
87	Fr francium —	88	Ra radium —	actinoids				103	104	Rf rutherfordium —	105	Db dubnium —	106	Sg seaborgium —	107	Bh bohrium —	108	Hs hassium —	109	Mt meitnerium —	110	Ds darmstadtium —	111	Rg roentgenium —	112	Cn copernicium —			114	Fl flerovium —	115	Lv livermorium —	116	—	—	—		