Write your name here

Surname: StemUp Model Solution | Other names:

Pearson Edexcel GCE

Centre Number | Candidate Number

Chemistry

Advanced Subsidiary

Paper 1: Core Inorganic and Physical Chemistry

Friday 27 May 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
8CH0/01

You must have:
Data Booklet
Calculator

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You may use a scientific calculator.
- For questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- Show all your working in calculations and include units where appropriate.

Turn over ▶

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Answer ALL questions.

Some questions must be answered with a cross in a box ☒.
If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about Group 7 elements and their compounds.

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

(1)

Chlorine is a gas and iodine is a solid.

(ii) Predict the physical state of astatine under these conditions. Justify your answer.

(1)

Astatine is a solid. It has more electrons than iodine, so the London forces between its molecules are stronger and need more energy to overcome.

(b) Write the equation for the reaction of chlorine with cold, dilute sodium hydroxide solution to form bleach. Name this type of reaction.

(2)

$Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$

Type of reaction *disproportionation*

(c) Hydrogen bromide gas reacts with ammonia gas

$$HBr + NH_3 \rightarrow NH_4Br$$

What would be observed during this reaction?

(1)

☒ **A** bubbles

☒ **B** decolorisation

☒ **C** steamy fumes

☒ **D** white smoke

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(d) State what is meant by the term electronegativity and hence explain the polarity, if any, of the **bonds** in chlorine trifluoride, ClF_3.

(3)

Electronegativity is the ability of an atom to attract the bonding pair of electrons in a covalent bond.

Fluorine is more electronegative than chlorine (fluorine is the most electronegative element).

So each of the three Cl-F bonds is polar: the fluorine atoms are δ− and the chlorine atom is δ+.

(e) What is the number of ions in 9.53 g of magnesium chloride, $MgCl_2$?

[Avogadro constant = 6.02×10^{23} mol^{-1}]

(1)

☒ **A** 6.02×10^{22}

☒ **B** 1.20×10^{23}

☒ **C** 1.81×10^{23}

☒ **D** 6.02×10^{23}

(Total for Question 1 = 9 marks)

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2 This question is about the structure of the atom and isotopes.

The following excerpt is taken from the book *Inorganic Chemistry* by Bailey and Snellgrove, fourth impression 1938.

> *"Some of the electrons are also contained in the nucleus, whilst the remainder are ..... arranged in rings revolving round the nucleus ..... The two isotopes [of chlorine] have therefore 18 and 20 electrons respectively in the nucleus and 17 [electrons] external to it."*

(a) Identify and correct **two** errors in the excerpt.

(2)

There are no electrons in the nucleus; the nucleus contains only protons and neutrons.

The two isotopes have 18 and 20 neutrons (not electrons) in the nucleus; both isotopes have 17 electrons.

(b) What is the structure of a 1+ ion of the carbon-13 isotope?

(1)

- ☒ **A** six protons, six neutrons and five electrons
- ☒ **B** six protons, seven neutrons and six electrons
- ☒ **C** six protons, seven neutrons and five electrons
- ☒ **D** seven protons, six neutrons and six electrons

(c) (i) State what is meant by the term **relative atomic mass**.

(2)

The relative atomic mass is the weighted mean (average) mass of an atom of an element, compared to 1/12th of the mass of an atom of carbon-12.

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(ii) A 5.000 g sample of lithium, containing the two isotopes lithium-6 and lithium-7, was found to contain 0.460 g of the isotope lithium-6.

Calculate the relative atomic mass of lithium for this sample. Give your answer to an appropriate number of significant figures.

Isotope	Relative isotopic mass
Lithium-6	6.015
Lithium-7	7.016

(3)

mass of lithium-7 = 5.000 − 0.460 = 4.540 g

% lithium-6 = 0.460 ÷ 5.000 × 100 = 9.2 %

% lithium-7 = 4.540 ÷ 5.000 × 100 = 90.8 %

A_r = (9.2 × 6.015 + 90.8 × 7.016) ÷ 100 = 6.9239

relative atomic mass = 6.92

(d) A mass spectrometer was used to analyse a sample of bromine, Br_2, with only the ^{79}Br and ^{81}Br isotopes present.

Explain why a very small peak occurs at $m/z = 80$.

(2)

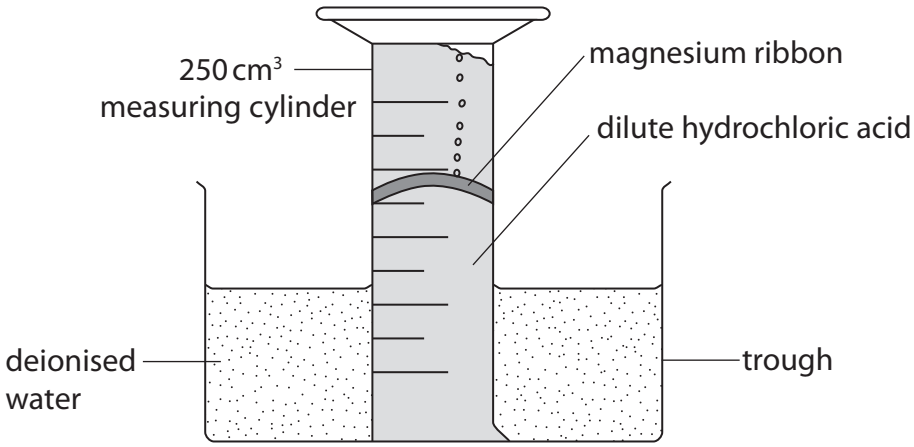
The Br_2 molecules have masses of 158, 160 and 162 (a molecule of $^{79}Br^{81}Br$ has a mass of 160).

A few of these molecules lose two electrons to form Br_2^{2+} ions, and $^{79}Br^{81}Br^{2+}$ has m/z = 160 ÷ 2 = 80.

(Total for Question 2 = 10 marks)

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3 A student used the apparatus in the diagram to determine the molar volume of a gas.



Assume clamps are in place to secure the apparatus

The student used a piece of magnesium ribbon, which was about 5 cm in length, and the dilute hydrochloric acid was in excess. The experiment was repeated three times at 24 °C and the following results were obtained.

	Experiment 1	Experiment 2	Experiment 3
Mass of magnesium / g	0.04	0.04	0.04
Volume of hydrogen gas / cm^3	31	25	32

The equation for the reaction is

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

(a) (i) Calculate the number of moles of magnesium used by the student in each experiment.

(1)

$n(Mg) = 0.04 \div 24.3 = 0.001646$ mol

(ii) Use your answer from part (a)(i) to deduce the number of moles of hydrogen gas that should be produced.

(1)

$n(H_2) = n(Mg) = 0.001646$ mol (1 : 1 ratio)

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(iii) Calculate, using the Ideal Gas Equation, the volume of hydrogen gas, in **cm³**, that should be produced in each of these experiments.

[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1} $p = 101\,000$ Pa]

(4)

$T = 24 + 273 = 297$ K

$pV = nRT$, so $V = nRT \div p$

$V = (0.001646 \times 8.31 \times 297) \div 101\,000$

$V = 4.022 \times 10^{-5}$ m^3

$V = 4.022 \times 10^{-5} \times 10^{6} = 40$ cm^3

(b) Give a reason why the student repeated the experiment three times.

(1)

To identify any anomalous results so they can be discarded, to improve the reliability of the results.

(c) Give three reasons for the difference between your calculated value in (a)(iii) and the actual volumes of hydrogen gas obtained by the student.

For each reason, identify a change to either the apparatus or the chemicals that could be made by the student to improve the result.

(6)

Some hydrogen escapes from the apparatus before the measuring cylinder is in place; use a sealed apparatus, a conical flask with a bung connected to a gas syringe.

The magnesium ribbon is covered with an oxide layer; clean the ribbon with an abrasive (emery paper) before weighing it.

The mass of magnesium (0.04 g) is too small to be measured accurately on the balance; use a more precise balance or use a larger mass of magnesium, so the percentage error is less.

(Total for Question 3 = 13 marks)

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4 The labels on four colourless solutions had fallen off in storage. It was known that the solutions were:

hydrochloric acid	magnesium sulfate
potassium chloride	sodium carbonate

In order to identify each solution, a number of tests were carried out.

(a) Solutions can be sprayed into a flame to produce a flame colour identical to that seen in the more conventional method with a solid on a nichrome wire.

Which solution would produce a lilac flame?

(1)

☒ **A** hydrochloric acid

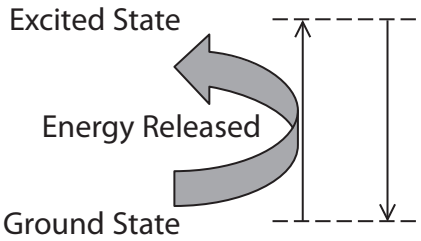
☒ **B** magnesium sulfate

☒ **C** potassium chloride

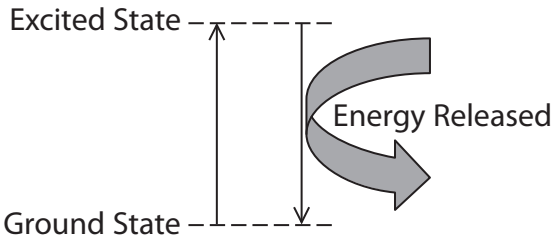
☒ **D** sodium carbonate

(b) Which of the following diagrams best illustrates the electronic transitions that take place during a flame test?

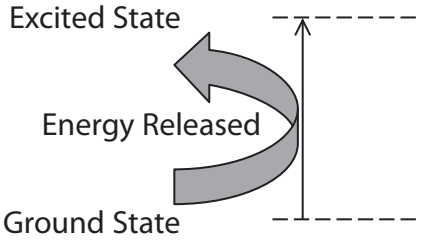
(1)



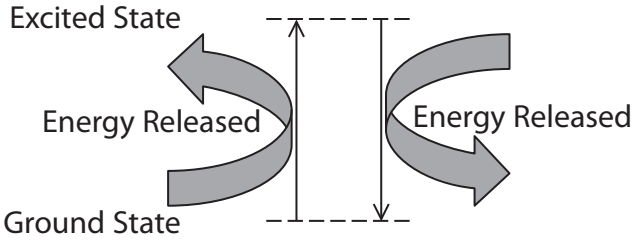
☒ **A**



☒ **B**



☒ **C**



☒ **D**

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(c) Which solution produces a white precipitate with acidified barium chloride solution?

(1)

- ☒ **A** hydrochloric acid
- ☒ **B** magnesium sulfate
- ☒ **C** potassium chloride
- ☒ **D** sodium carbonate

(d) Two of the solutions produce the same result on the addition of dilute nitric acid followed by silver nitrate solution.

State the observation with this test and the **two** solutions that give this result.

(2)

Observation *white precipitate*

Solutions *hydrochloric acid and potassium chloride*

(e) The hydrochloric acid and the sodium carbonate solution react together. State an observation you would make and write the **ionic** equation for the reaction. State symbols are not required.

(2)

Observation *fizzing (effervescence)*

Ionic equation

$2H^+ + CO_3^{2-} \rightarrow CO_2 + H_2O$

(Total for Question 4 = 7 marks)

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5 A solution of nitric acid, HNO_3, of concentration 100 g dm^{-3}, can be used to artificially age wood.

A sample of nitric acid, thought to be suitable for this use, was diluted by pipetting 10.00 cm^3 of this acid into a 250 cm^3 volumetric flask, adding deionised water and making the solution up to the mark. The solution was thoroughly mixed.

A titration was carried out using this diluted solution of nitric acid. The burette was filled with 0.0800 mol dm^{-3} sodium hydroxide solution and 25.00 cm^3 of the diluted nitric acid was pipetted into each of three conical flasks. The following results were obtained.

	Titration 1	Titration 2	Titration 3
Final burette reading / cm^3	20.50	40.40	20.00
Initial burette reading / cm^3	0.00	20.50	0.00
Volume added / cm^3	20.50	19.90	20.00

The equation for the reaction is

$$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$$

(a) Select the appropriate titres and calculate the mean titre in cm^3.

(1)

Titres 2 and 3 are concordant (titration 1 is not used):

mean titre = (19.90 + 20.00) ÷ 2 = 19.95 cm^3

(b) Calculate the concentration of the **undiluted** nitric acid in g dm^{-3}. Give your answer to one decimal place.

Deduce whether this nitric acid is suitable for use in artificially ageing wood.

(5)

$n(NaOH) = 19.95 \times 0.0800 \div 1000 = 1.596 \times 10^{-3}$ mol $= n(HNO_3)$

diluted $[HNO_3] = 1.596 \times 10^{-3} \times 1000 \div 25.00 = 0.06384$ mol dm^{-3}

undiluted $[HNO_3] = 0.06384 \times 250 \div 10.00 = 1.596$ mol dm^{-3}

$M(HNO_3) = 1.0 + 14.0 + (3 \times 16.0) = 63.0$ g mol^{-1}

concentration $= 1.596 \times 63.0 = 100.5$ g dm^{-3}

Suitable: 100.5 g dm^{-3} is very close to 100 g dm^{-3}.

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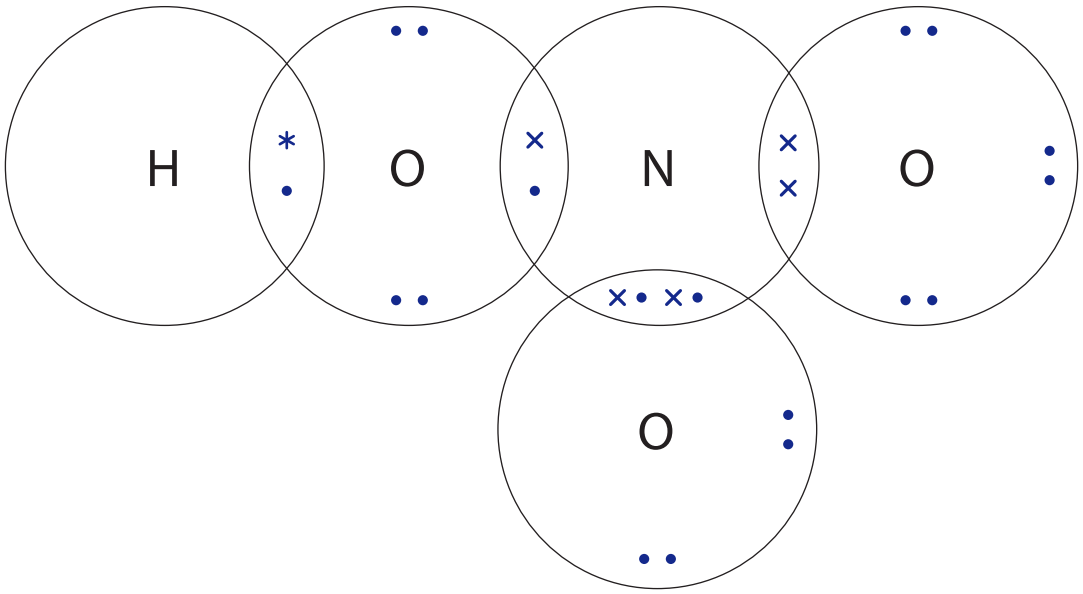
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(c) Complete the dot-and-cross diagram for the bonding in nitric acid, showing only outer shell electrons.

Use (•) for the oxygen electrons,

(**x**) for the nitrogen electrons and (*) for the hydrogen electron.

(3)



(d) One possible method for the formation of nitric acid involves the reaction between dinitrogen tetroxide and water.

$$3N_2O_4 + 2H_2O \rightarrow 4HNO_3 + 2NO$$

Calculate the atom economy for the formation of nitric acid from this reaction.

(1)

$M_r(4HNO_3) = 4 \times 63.0 = 252$ $M_r(2NO) = 2 \times 30.0 = 60$

atom economy $= 252 \div (252 + 60) \times 100 = 80.8\ \%$

(Total for Question 5 = 10 marks)

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6 (a) The diagram shows bond angles in ammonia and water.



Explain why the bond angle in water is less than the bond angle in ammonia.

(2)

The oxygen atom in water has two lone pairs of electrons but the nitrogen atom in ammonia has only one lone pair.

Lone pair-lone pair repulsion is greater than lone pair-bond pair repulsion, so the bond angle in water is reduced more.

(b) Explain why the O—H and S—H bond lengths are different.



(3)

A sulfur atom is larger than an oxygen atom: sulfur has a larger atomic radius because it has more shells of electrons.

So sulfur has more inner shell electrons, giving greater shielding of its nucleus.

This reduces the attraction of the sulfur nucleus for the bonding pair of electrons, so the S-H bond is longer than the O-H bond.

(Total for Question 6 = 5 marks)

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7 *(a) A student suggested that the difference in the rates of reaction of strontium and barium with water is due to the difference in the sum of their first and second ionisation energies. Discuss this suggestion.

(6)

The student is correct that barium reacts faster with water than strontium (barium is more reactive), and this can be explained by ionisation energies.

When each metal reacts with water it loses its two outer electrons to form a 2+ ion, so the sum of the first and second ionisation energies shows how easily this happens.

The sum of the first and second ionisation energies of barium is lower than that of strontium, so barium loses its outer electrons more easily.

This is because a barium atom is larger than a strontium atom: it has more shells of electrons, so its outer electrons are further from the nucleus.

Barium also has more shielding from its extra inner shells of electrons.

These factors outweigh the greater nuclear charge (more protons) of barium, so its outer electrons are less strongly attracted and are removed more easily.

Therefore barium reacts faster with water, which supports the suggestion.

(b) Which is the equation for the **third** ionisation energy of barium?

(1)

- ☐ **A** $Ba(s) \rightarrow Ba^{3+}(g) + 3e^-$
- ☐ **B** $Ba^{2+}(s) \rightarrow Ba^{3+}(g) + e^-$
- ☒ **C** $Ba^{2+}(g) \rightarrow Ba^{3+}(g) + e^-$
- ☐ **D** $Ba^{3+}(g) \rightarrow Ba^{4+}(g) + e^-$

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(c) Explain why magnesium nitrate, $Mg(NO_3)_2$ decomposes more readily on heating than potassium nitrate, KNO_3.

(4)

The magnesium ion (Mg^{2+}) is smaller than the potassium ion (K^+).

The magnesium ion also has a higher charge (2+ compared with 1+), so it has a higher charge density.

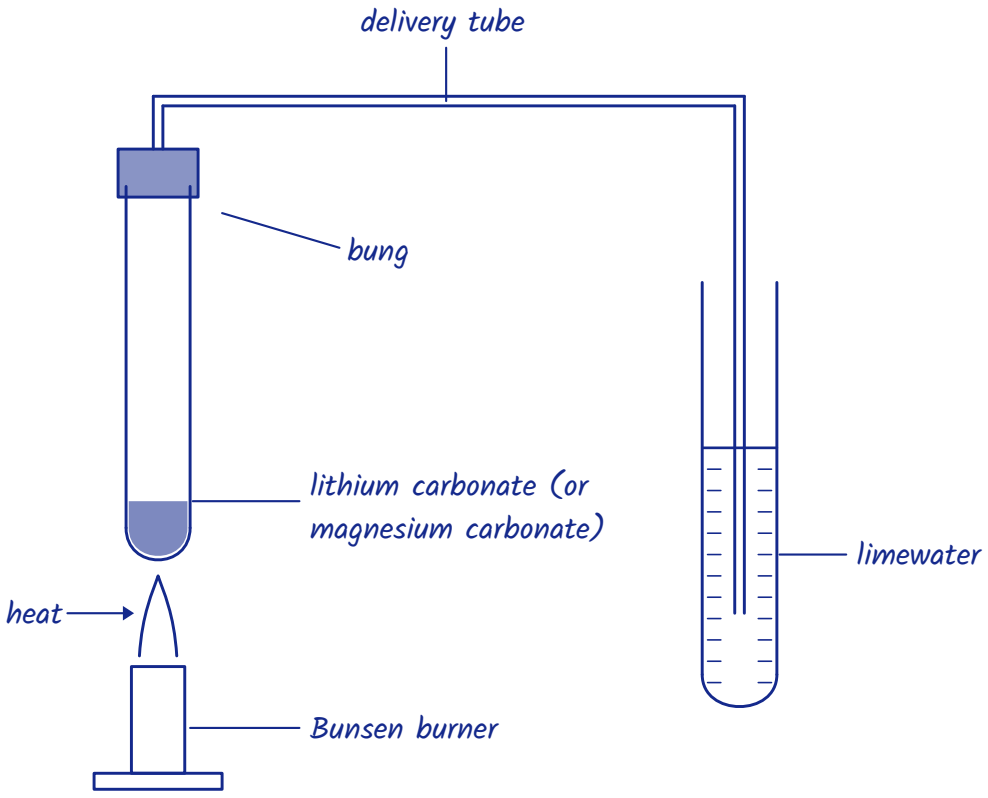
So the magnesium ion polarises the nitrate ion more: it distorts the electron cloud of the nitrate ion more.

This weakens the N-O bonds in the nitrate ion more, so magnesium nitrate decomposes more readily.

(d) Some metal carbonates also undergo thermal decomposition.

(i) Draw a diagram of the apparatus that could be used to compare the ease of thermal decomposition of lithium carbonate, Li_2CO_3, and magnesium carbonate, $MgCO_3$.

(2)



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(ii) State **one** way in which you would ensure a fair test.

(1)

Use the same Bunsen burner setting (same flame) and keep the same distance between the flame and the test tube.

(iii) State how data obtained in this experiment could be used to make a comparison.

(1)

Measure the time taken for the limewater to turn cloudy: the shorter the time, the more easily the carbonate decomposes.

(Total for Question 7 = 15 marks)

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8 The properties of elements and their compounds are determined by their structure and bonding.

(a) Magnesium oxide has a very high melting temperature.
Which of the following is the best description of its structure and bonding?

(1)

☒ **A** giant ionic

☐ **B** giant metallic

☐ **C** giant covalent

☐ **D** simple covalent

(b) Sulfur reacts with fluorine to form a number of different compounds.

(i) One compound contains 45.79% sulfur and 54.21% fluorine by mass.
Calculate the empirical formula of this compound.

(2)

$n(S) = 45.79 \div 32.1 = 1.426$ $n(F) = 54.21 \div 19.0 = 2.853$

$S : F = 1.426 : 2.853 = 1 : 2$

empirical formula = SF_2

(ii) In a dry container, a fluoride of silver reacts with sulfur to produce disulfur difluoride. Complete the equation for this reaction.
State symbols are not required.

(1)

$$S_8 + \underline{8}\,AgF_2 \rightarrow \underline{4}\,S_2F_2 + \underline{8}\,AgF$$

(iii) Explain, by using the oxidation numbers of **all** the atoms, whether or not this is a redox reaction.

(3)

Sulfur: 0 in S_8 and +1 in S_2F_2, so its oxidation number increases and sulfur is oxidised.

Silver: +2 in AgF_2 and +1 in AgF, so its oxidation number decreases and silver is reduced.

Fluorine is −1 in AgF_2, S_2F_2 and AgF, so it does not change.

So this is a redox reaction, as sulfur is oxidised and silver is reduced.

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(c) Element **X** has the typical appearance of a metal.

Predict **two** other distinct physical properties that element **X** would exhibit if it is a metal. Explain your choices in terms of structure and bonding.

(4)

High melting temperature: there is strong electrostatic attraction between the positive metal ions and the delocalised electrons, which needs a lot of energy to overcome.

Good electrical conductivity: the delocalised electrons are mobile, so they can move through the structure and carry charge.

(Total for Question 8 = 11 marks)

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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