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Candidate surname					Other names				
Centre Number					Candidate Number				
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Pearson Edexcel International GCSE (9–1)

Friday 17 May 2024

Morning (Time: 2 hours)	Paper reference	4CH1/1CR 4SD0/1CR
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Chemistry

UNIT: 4CH1

Science (Double Award) 4SD0

PAPER: 1CR

You must have: Calculator, ruler	Total Marks
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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.*
- Show all the steps in any calculations and state the units.

Information

- The total mark for this paper is 110.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Write your answers neatly and in good English.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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The Periodic Table of the Elements

1	2	3	4	5	6	7	0	
7 Li lithium 3	9 Be beryllium 4	11 Na sodium 11	12 C carbon 6	13 Al aluminium 13	14 N nitrogen 7	15 O oxygen 8	16 F fluorine 9	17 Ne neon 10
19 K potassium 19	20 Ca calcium 20	23 Sc scandium 21	24 Ti titanium 22	25 V vanadium 23	26 Cr chromium 24	27 Mn manganese 25	28 Fe iron 26	29 Co cobalt 27
37 Rb rubidium 37	38 Sr strontium 38	39 Y yttrium 39	40 Zr zirconium 40	41 Nb niobium 41	42 Mo molybdenum 42	43 Tc technetium 43	44 Ru ruthenium 44	45 Rh rhodium 45
55 Cs caesium 55	56 Ba barium 56	57 La* lanthanum 57	58 Hf hafnium 58	59 Ta tantalum 59	60 W tungsten 60	61 Re rhenium 61	62 Os osmium 62	63 Ir iridium 63
87 Fr francium 87	88 Ra radium 88	89 Ac* actinium 89	90 Rf rutherfordium 90	91 Db dubnium 91	92 Sg seaborgium 92	93 Bh bohrium 93	94 Hs hassium 94	95 Mt meitnerium 95
133 Cs caesium 133	137 Ba barium 137	138 La* lanthanum 138	139 Hf hafnium 139	140 Ta tantalum 140	141 W tungsten 141	142 Re rhenium 142	143 Os osmium 143	144 Ir iridium 144
187 Rb rubidium 187	188 Sr strontium 188	189 Y yttrium 189	190 Zr zirconium 190	191 Nb niobium 191	192 Mo molybdenum 192	193 Tc technetium 193	194 Ru ruthenium 194	195 Rh rhodium 195
223 Fr francium 223	226 Ra radium 226	227 Ac* actinium 227	228 Rf rutherfordium 228	229 Db dubnium 229	230 Sg seaborgium 230	231 Bh bohrium 231	232 Hs hassium 232	233 Mt meitnerium 233
285 Cs caesium 285	286 Ba barium 286	287 La* lanthanum 287	288 Hf hafnium 288	289 Ta tantalum 289	290 W tungsten 290	291 Re rhenium 291	292 Os osmium 292	293 Ir iridium 293
339 Rb rubidium 339	340 Sr strontium 340	341 Y yttrium 341	342 Zr zirconium 342	343 Nb niobium 343	344 Mo molybdenum 344	345 Tc technetium 345	346 Ru ruthenium 346	347 Rh rhodium 347
449 Cs caesium 449	450 Ba barium 450	451 La* lanthanum 451	452 Hf hafnium 452	453 Ta tantalum 453	454 W tungsten 454	455 Re rhenium 455	456 Os osmium 456	457 Ir iridium 457
589 Rb rubidium 589	590 Sr strontium 590	591 Y yttrium 591	592 Zr zirconium 592	593 Nb niobium 593	594 Mo molybdenum 594	595 Tc technetium 595	596 Ru ruthenium 596	597 Rh rhodium 597
729 Cs caesium 729	730 Ba barium 730	731 La* lanthanum 731	732 Hf hafnium 732	733 Ta tantalum 733	734 W tungsten 734	735 Re rhenium 735	736 Os osmium 736	737 Ir iridium 737
879 Rb rubidium 879	880 Sr strontium 880	881 Y yttrium 881	882 Zr zirconium 882	883 Nb niobium 883	884 Mo molybdenum 884	885 Tc technetium 885	886 Ru ruthenium 886	887 Rh rhodium 887
1029 Cs caesium 1029	1030 Ba barium 1030	1031 La* lanthanum 1031	1032 Hf hafnium 1032	1033 Ta tantalum 1033	1034 W tungsten 1034	1035 Re rhenium 1035	1036 Os osmium 1036	1037 Ir iridium 1037
1379 Rb rubidium 1379	1380 Sr strontium 1380	1381 Y yttrium 1381	1382 Zr zirconium 1382	1383 Nb niobium 1383	1384 Mo molybdenum 1384	1385 Tc technetium 1385	1386 Ru ruthenium 1386	1387 Rh rhodium 1387
1679 Cs caesium 1679	1680 Ba barium 1680	1681 La* lanthanum 1681	1682 Hf hafnium 1682	1683 Ta tantalum 1683	1684 W tungsten 1684	1685 Re rhenium 1685	1686 Os osmium 1686	1687 Ir iridium 1687
2239 Rb rubidium 2239	2240 Sr strontium 2240	2241 Y yttrium 2241	2242 Zr zirconium 2242	2243 Nb niobium 2243	2244 Mo molybdenum 2244	2245 Tc technetium 2245	2246 Ru ruthenium 2246	2247 Rh rhodium 2247
2839 Cs caesium 2839	2840 Ba barium 2840	2841 La* lanthanum 2841	2842 Hf hafnium 2842	2843 Ta tantalum 2843	2844 W tungsten 2844	2845 Re rhenium 2845	2846 Os osmium 2846	2847 Ir iridium 2847
3529 Rb rubidium 3529	3530 Sr strontium 3530	3531 Y yttrium 3531	3532 Zr zirconium 3532	3533 Nb niobium 3533	3534 Mo molybdenum 3534	3535 Tc technetium 3535	3536 Ru ruthenium 3536	3537 Rh rhodium 3537
4499 Cs caesium 4499	4500 Ba barium 4500	4501 La* lanthanum 4501	4502 Hf hafnium 4502	4503 Ta tantalum 4503	4504 W tungsten 4504	4505 Re rhenium 4505	4506 Os osmium 4506	4507 Ir iridium 4507
5899 Rb rubidium 5899	5900 Sr strontium 5900	5901 Y yttrium 5901	5902 Zr zirconium 5902	5903 Nb niobium 5903	5904 Mo molybdenum 5904	5905 Tc technetium 5905	5906 Ru ruthenium 5906	5907 Rh rhodium 5907
7299 Cs caesium 7299	7300 Ba barium 7300	7301 La* lanthanum 7301	7302 Hf hafnium 7302	7303 Ta tantalum 7303	7304 W tungsten 7304	7305 Re rhenium 7305	7306 Os osmium 7306	7307 Ir iridium 7307
8799 Rb rubidium 8799	8800 Sr strontium 8800	8801 Y yttrium 8801	8802 Zr zirconium 8802	8803 Nb niobium 8803	8804 Mo molybdenum 8804	8805 Tc technetium 8805	8806 Ru ruthenium 8806	8807 Rh rhodium 8807
10299 Cs caesium 10299	10300 Ba barium 10300	10301 La* lanthanum 10301	10302 Hf hafnium 10302	10303 Ta tantalum 10303	10304 W tungsten 10304	10305 Re rhenium 10305	10306 Os osmium 10306	10307 Ir iridium 10307
13799 Rb rubidium 13799	13800 Sr strontium 13800	13801 Y yttrium 13801	13802 Zr zirconium 13802	13803 Nb niobium 13803	13804 Mo molybdenum 13804	13805 Tc technetium 13805	13806 Ru ruthenium 13806	13807 Rh rhodium 13807
16799 Cs caesium 16799	16800 Ba barium 16800	16801 La* lanthanum 16801	16802 Hf hafnium 16802	16803 Ta tantalum 16803	16804 W tungsten 16804	16805 Re rhenium 16805	16806 Os osmium 16806	16807 Ir iridium 16807
22399 Rb rubidium 22399	22400 Sr strontium 22400	22401 Y yttrium 22401	22402 Zr zirconium 22402	22403 Nb niobium 22403	22404 Mo molybdenum 22404	22405 Tc technetium 22405	22406 Ru ruthenium 22406	22407 Rh rhodium 22407
28399 Cs caesium 28399	28400 Ba barium 28400	28401 La* lanthanum 28401	28402 Hf hafnium 28402	28403 Ta tantalum 28403	28404 W tungsten 28404	28405 Re rhenium 28405	28406 Os osmium 28406	28407 Ir iridium 28407
35299 Rb rubidium 35299	35300 Sr strontium 35300	35301 Y yttrium 35301	35302 Zr zirconium 35302	35303 Nb niobium 35303	35304 Mo molybdenum 35304	35305 Tc technetium 35305	35306 Ru ruthenium 35306	35307 Rh rhodium 35307
44999 Cs caesium 44999	45000 Ba barium 45000	45001 La* lanthanum 45001	45002 Hf hafnium 45002	45003 Ta tantalum 45003	45004 W tungsten 45004	45005 Re rhenium 45005	45006 Os osmium 45006	45007 Ir iridium 45007
58999 Rb rubidium 58999	59000 Sr strontium 59000	59001 Y yttrium 59001	59002 Zr zirconium 59002	59003 Nb niobium 59003	59004 Mo molybdenum 59004	59005 Tc technetium 59005	59006 Ru ruthenium 59006	59007 Rh rhodium 59007
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87999 Rb rubidium 87999	88000 Sr strontium 88000	88001 Y yttrium 88001	88002 Zr zirconium 88002	88003 Nb niobium 88003	88004 Mo molybdenum 88004	88005 Tc technetium 88005	88006 Ru ruthenium 88006	88007 Rh rhodium 88007
102999 Cs caesium 102999	103000 Ba barium 103000	103001 La* lanthanum 103001	103002 Hf hafnium 103002	103003 Ta tantalum 103003	103004 W tungsten 103004	103005 Re rhenium 103005	103006 Os osmium 103006	103007 Ir iridium 103007
137999 Rb rubidium 137999	138000 Sr strontium 138000	138001 Y yttrium 138001	138002 Zr zirconium 138002	138003 Nb niobium 138003	138004 Mo molybdenum 138004	138005 Tc technetium 138005	138006 Ru ruthenium 138006	138007 Rh rhodium 138007
167999 Cs caesium 167999	168000 Ba barium 168000	168001 La* lanthanum 168001	168002 Hf hafnium 168002	168003 Ta tantalum 168003	168004 W tungsten 168004	168005 Re rhenium 168005	168006 Os osmium 168006	168007 Ir iridium 168007
223999 Rb rubidium 223999	224000 Sr strontium 224000	224001 Y yttrium 224001	224002 Zr zirconium 224002	224003 Nb niobium 224003	224004 Mo molybdenum 224004	224005 Tc technetium 224005	224006 Ru ruthenium 224006	224007 Rh rhodium 224007
283999 Cs caesium 283999	284000 Ba barium 284000	284001 La* lanthanum 284001	284002 Hf hafnium 284002	284003 Ta tantalum 284003	284004 W tungsten 284004	284005 Re rhenium 284005	284006 Os osmium 284006	284007 Ir iridium 284007
352999 Rb rubidium 352999	353000 Sr strontium 353000	353001 Y yttrium 353001	353002 Zr zirconium 353002	353003 Nb niobium 353003	353004 Mo molybdenum 353004	353005 Tc technetium 353005	353006 Ru ruthenium 353006	353007 Rh rhodium 353007
449999 Cs caesium 449999	450000 Ba barium 450000	450001 La* lanthanum 450001	450002 Hf hafnium 450002	450003 Ta tantalum 450003	450004 W tungsten 450004	450005 Re rhenium 450005	450006 Os osmium 450006	450007 Ir iridium 450007
589999 Rb rubidium 589999	590000 Sr strontium 590000	590001 Y yttrium 590001	590002 Zr zirconium 590002	590003 Nb niobium 590003	590004 Mo molybdenum 590004	590005 Tc technetium 590005	590006 Ru ruthenium 590006	590007 Rh rhodium 590007
729999 Cs caesium 729999	730000 Ba barium 730000	730001 La* lanthanum 730001	730002 Hf hafnium 730002	730003 Ta tantalum 730003	730004 W tungsten 730004	730005 Re rhenium 730005	730006 Os osmium 730006	730007 Ir iridium 730007
879999 Rb rubidium 879999	880000 Sr strontium 880000	880001 Y yttrium 880001	880002 Zr zirconium 880002	880003 Nb niobium 880003	880004 Mo molybdenum 880004	880005 Tc technetium 880005	880006 Ru ruthenium 880006	880007 Rh rhodium 880007
1029999 Cs caesium 1029999	1030000 Ba barium 1030000	1030001 La* lanthanum 1030001	1030002 Hf hafnium 1030002	1030003 Ta tantalum 1030003	1030004 W tungsten 1030004	1030005 Re rhenium 1030005	1030006 Os os	

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Answer ALL questions.

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

1 This question is about atomic structure.

- (a) The table shows the number of protons, neutrons and electrons in five species, V, W, X, Y and Z.

The letters represent the species but are **not** symbols from the Periodic Table.

Species	Number of protons	Number of neutrons	Number of electrons
V	29	38	27
W	12	12	12
X	9	10	10
Y	6	6	8
Z	7	7	10

Choose letters from the table to answer these questions.

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

- (i) Which species is an atom? (1)

- (ii) Which species is an ion with a positive charge? (1)

- (iii) Which species is an ion with a 3⁻ charge? (1)

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(b) (i) State what is meant by the term **atomic number**.

(1)

(ii) State what is meant by the term **mass number**.

(1)

(Total for Question 1 = 5 marks)

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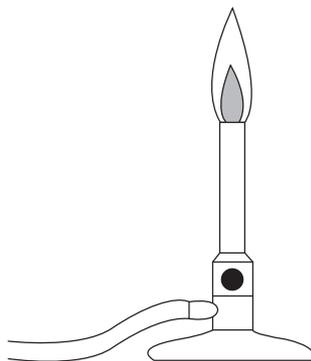
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2 This question is about methane, CH₄

The diagram shows a Bunsen burner that uses methane.



(a) During combustion, methane reacts with a gas in the air.

Give the name of this gas.

(1)

(b) Give the two products of the complete combustion of methane.

(2)

(c) During the incomplete combustion of methane, carbon monoxide forms.

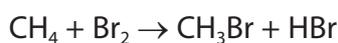
(i) Give a reason why carbon monoxide forms during incomplete combustion.

(1)

(ii) State why carbon monoxide is poisonous.

(1)

(d) The equation shows the reaction of methane with bromine.



Give the name of this type of chemical reaction.

(1)

(Total for Question 2 = 6 marks)



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3 This question is about elements, mixtures and compounds.

(a) The box gives some methods used to separate mixtures.

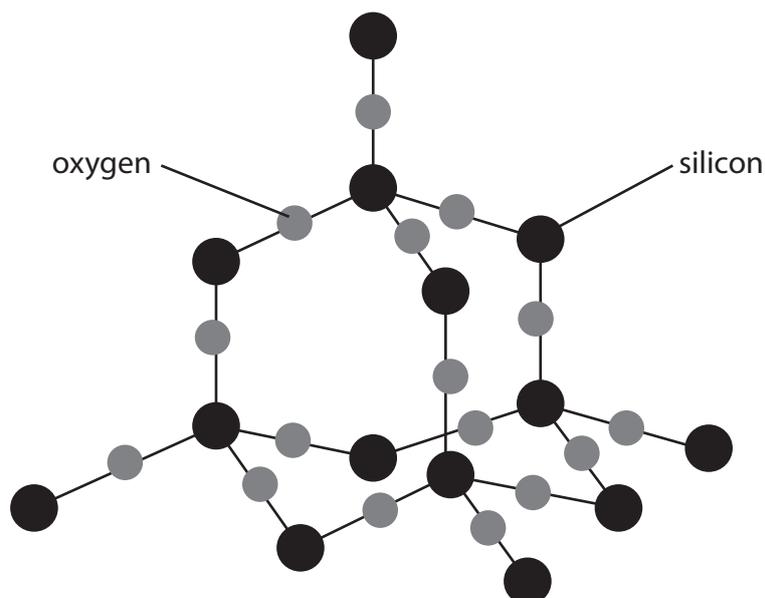
crystallisation	filtration
fractional distillation	simple distillation

Choose methods from the box to answer these questions.

(i) Identify a method to remove sand from a mixture of sand and seawater. (1)

(ii) Identify a method to separate a mixture of liquids with different boiling points. (1)

(b) The diagram shows part of the structure of silicon dioxide.



Explain why silicon dioxide is a compound. (2)

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(c) The molecular formula of the compound insulin is $C_{257}H_{383}N_{65}O_{77}S_6$

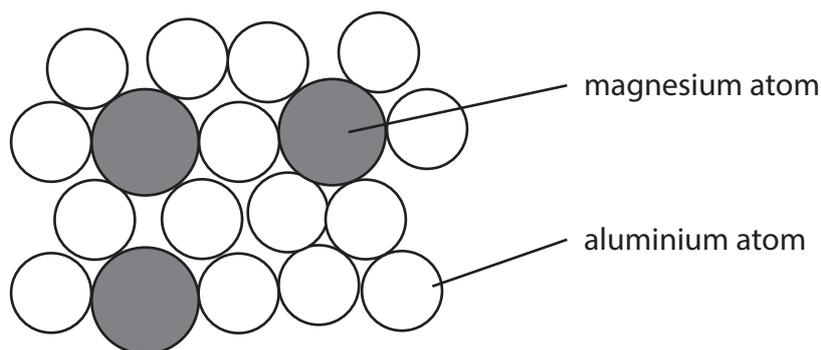
(i) Determine the number of different elements in $C_{257}H_{383}N_{65}O_{77}S_6$ (1)

(ii) Determine the number of atoms in a molecule of $C_{257}H_{383}N_{65}O_{77}S_6$ (1)

number of atoms =

(d) Magnalium is a mixture of magnesium atoms and aluminium atoms.

The diagram shows a sample of magnalium.



Calculate the percentage of magnesium atoms in this sample.

(2)

percentage = %

(Total for Question 3 = 8 marks)

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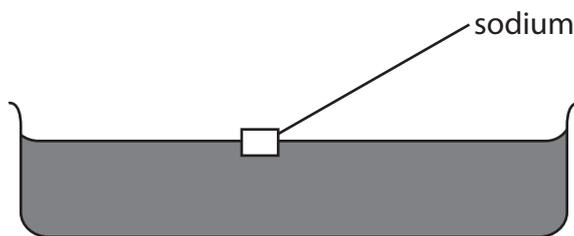
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4 This question is about the alkali metals.

A teacher demonstrates the reaction between sodium and water.

The teacher fills a trough with water and then adds a piece of sodium.



(a) The sodium reacts with the water, forming bubbles of hydrogen gas and a colourless solution.

State two other observations that would be made.

(2)

1

2

(b) Give a test to show that, at the end of the reaction, the solution contains sodium ions.

(2)

.....

.....

.....

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(c) Lithium, sodium and potassium react in a similar way when added to water.

- (i) State, with reference to the electronic configurations of atoms, why these elements have similar reactions.

(1)

- (ii) The table shows the atomic radius of a lithium atom, a sodium atom and a potassium atom.

Atom	Atomic radius in cm
lithium	1.82×10^{-12}
sodium	2.27×10^{-12}
potassium	2.80×10^{-12}

Deduce the relationship between the atomic radius and the reactivity of the metals.

(1)

(Total for Question 4 = 6 marks)

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5 Chromatography is used to separate the components in a mixture.

(a) Diagram 1 shows the apparatus used to separate the different dyes in a food colouring.

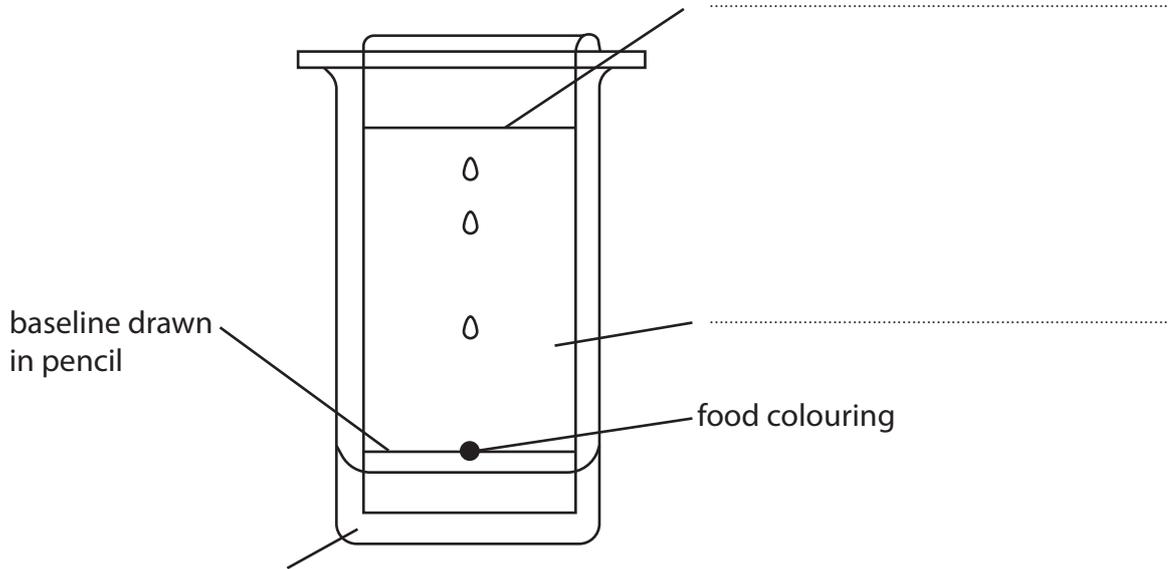


Diagram 1

(i) Complete the diagram by adding the missing labels.

(3)

(ii) Give a reason why the baseline is drawn in pencil.

(1)

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- (b) Diagram 2 shows a chromatogram produced from four different food colourings, W, X, Y and Z.

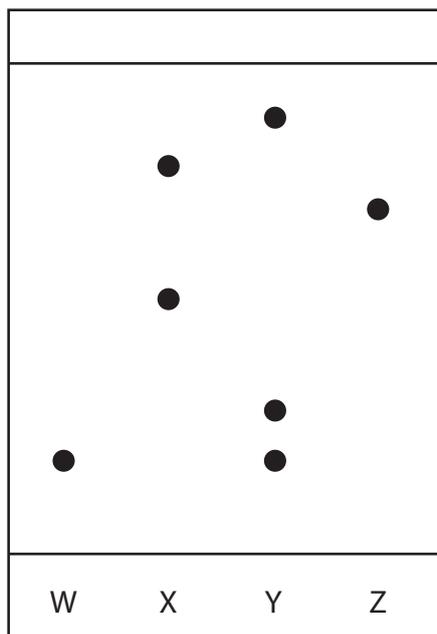


Diagram 2

- (i) Which two food colourings contain the same dye?

(1)

- A** W and X
- B** W and Y
- C** X and Z
- D** Y and Z

- (ii) Calculate the R_f value of the dye in food colouring W.

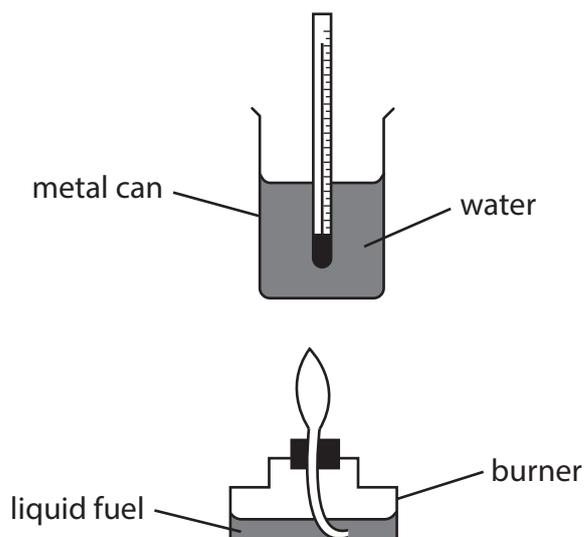
(2)

$R_f = \dots\dots\dots$

(Total for Question 5 = 7 marks)



- 6 A student uses this apparatus to find the heat energy released by the combustion of liquid fuels.



- (a) Explain what is meant by the term **fuel**.

(2)

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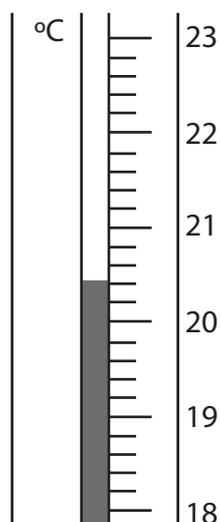
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- (b) (i) In one experiment, the student uses liquid ethanol as the fuel.

The thermometer shows the temperature of the water at the start of the experiment.



Complete the table by giving the temperatures to the nearest 0.1 °C.

(2)

temperature of the water at the start in °C	
highest temperature reached in °C	
temperature rise in °C	57.2

- (ii) The metal can contains water of mass 150 g.

Show, by calculation, that the heat energy change (Q) for this reaction is approximately 36 000 J.

[for water, $c = 4.2 \text{ J/g/}^\circ\text{C}$]

(2)

$$Q = \dots\dots\dots \text{ J}$$

- (iii) In the experiment, 2.3 g of ethanol ($M_r = 46$) is burned.

Calculate the molar enthalpy change (ΔH), in kJ/mol, for the combustion of ethanol, $\text{C}_2\text{H}_5\text{OH}$

Include a sign in your answer.

Give your answer to two significant figures.

(4)

$$\Delta H = \dots\dots\dots \text{ kJ/mol}$$

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(c) In this experiment, the calculated value of ΔH is less than the value given in a data book.

Give a possible reason for the difference in values.

(1)

(Total for Question 6 = 11 marks)

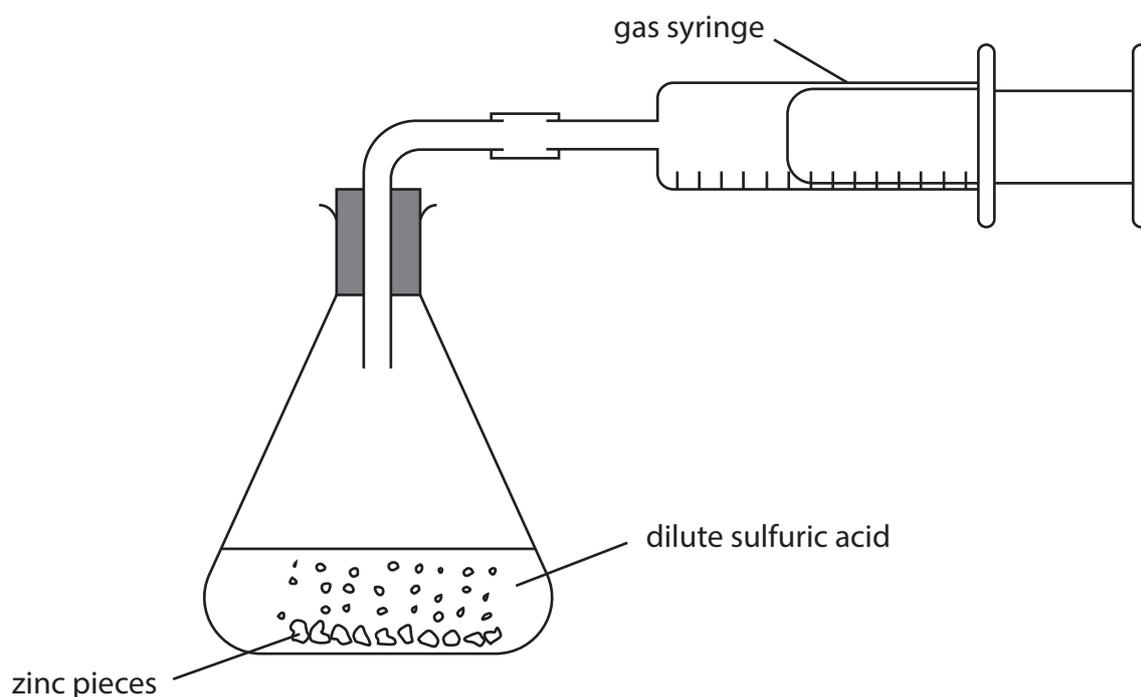
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- 7 A student uses this apparatus to investigate the rate of reaction between dilute sulfuric acid and an excess of small pieces of zinc.



This is the student's method.

Step 1 use 50 cm³ of dilute sulfuric acid

Step 2 add approximately 5 g of small zinc pieces to the sulfuric acid

Step 3 quickly connect the gas syringe

Step 4 record the reading on the gas syringe every 30 seconds until the reaction stops

- (a) (i) Name a suitable piece of apparatus to measure the volume of sulfuric acid. (1)

- (ii) Give a reason why the mass of zinc pieces does not need to be measured accurately. (1)

- (iii) Give a reason why the student quickly connects the gas syringe in step 3. (1)



(iv) State how the student would know when the reaction stops.

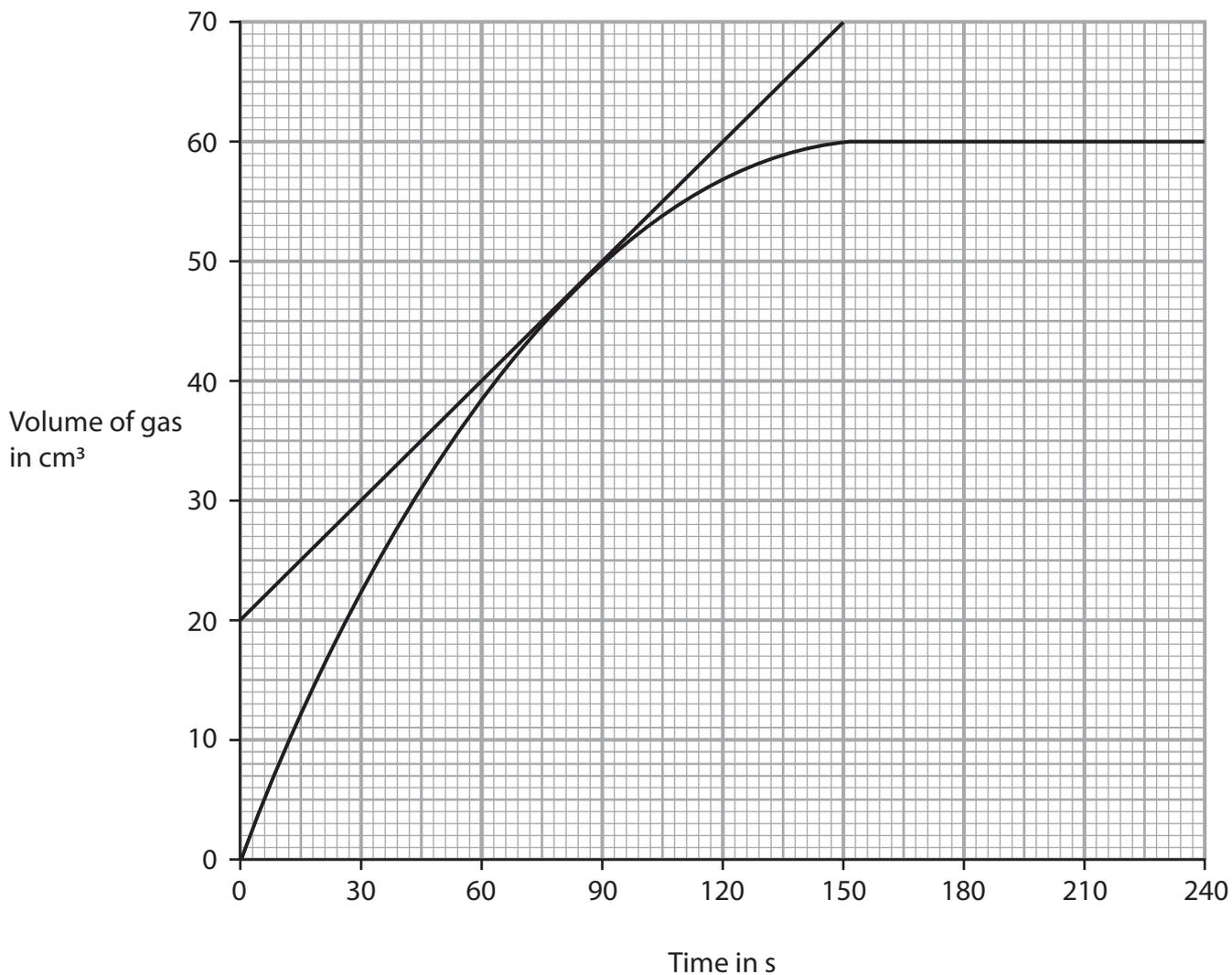
(1)

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(b) The graph shows the volume of gas collected in the syringe during the experiment.



(i) A tangent to the curve has been drawn at a time of 80 s.

Use the tangent to calculate the rate of reaction at 80 s.

Show your working on the graph.

Give the unit.

(3)

rate of reaction = unit



(ii) Explain the shape of the graph in these regions.

(6)

from 0 s to 60 s

from 60 s to 150 s

from 150 s to 240 s

(Total for Question 7 = 13 marks)

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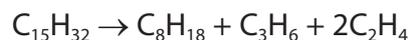
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(b) Some of the products of fractional distillation are then cracked.

This equation represents a reaction that occurs during cracking.



Explain why cracking is an important process in the oil industry.

(4)

(c) Fuels obtained from crude oil may contain impurities.

Explain how an impurity found in fuels can cause an environmental problem.

(3)

(Total for Question 8 = 11 marks)



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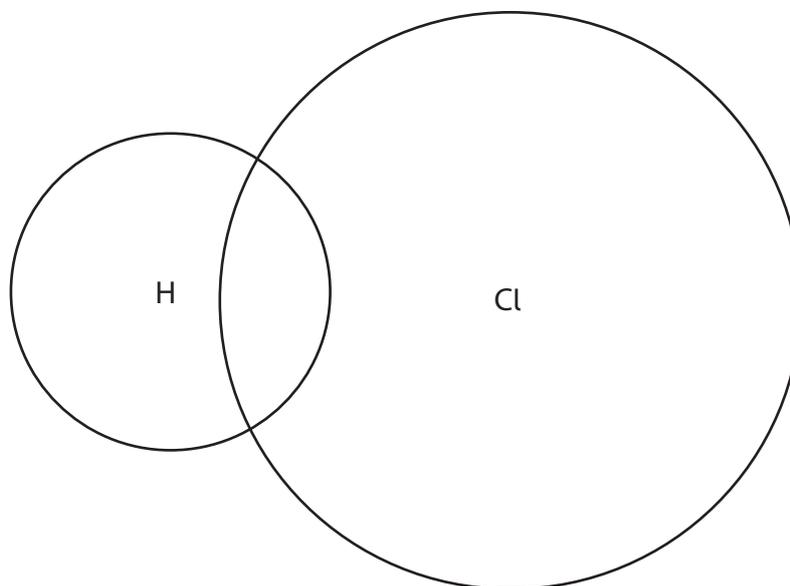
- 9 (a) The table shows the formulae of some positive and negative ions, and the formulae of some compounds containing these ions.

	Cl^-	O^{2-}	SO_4^{2-}
Na^+		Na_2O	Na_2SO_4
NH_4^+	NH_4Cl		
Zn^{2+}	ZnCl_2		ZnSO_4

- (i) Complete the table by giving the formulae of the missing compounds. (3)
- (ii) Give the name of the compound with the formula ZnSO_4 . (1)

- (b) Hydrogen chloride and magnesium chloride have different types of bonding and have different structures.

- (i) Complete the dot-and-cross diagram to show the outer shell electrons in a molecule of hydrogen chloride. (2)



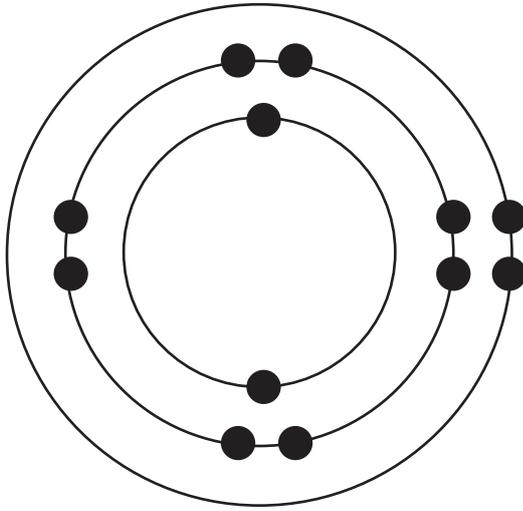
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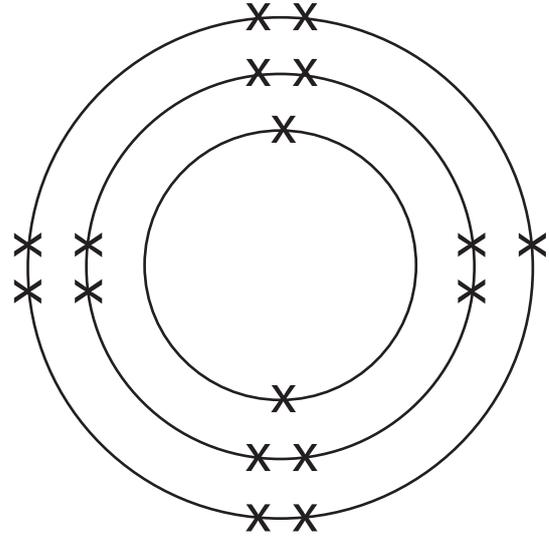
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- (ii) The diagram shows the electronic configuration of a magnesium atom and of a chlorine atom.



magnesium



chlorine

Draw the electronic configuration of a magnesium ion and of a chloride ion in the boxes.

Show the charge on each ion.

(3)

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magnesium ion

chloride ion



- (iii) Explain why magnesium chloride has a much higher melting point than hydrogen chloride.

Refer to structure and bonding in your answer.

(5)

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(Total for Question 9 = 14 marks)



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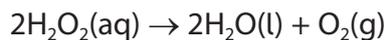
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P 7 3 4 2 4 A 0 2 5 3 2

10 This is the equation for the decomposition of hydrogen peroxide.



The rate of reaction increases when a catalyst of manganese(IV) oxide is added.

(a) Describe how a catalyst increases the rate of a reaction.

(2)

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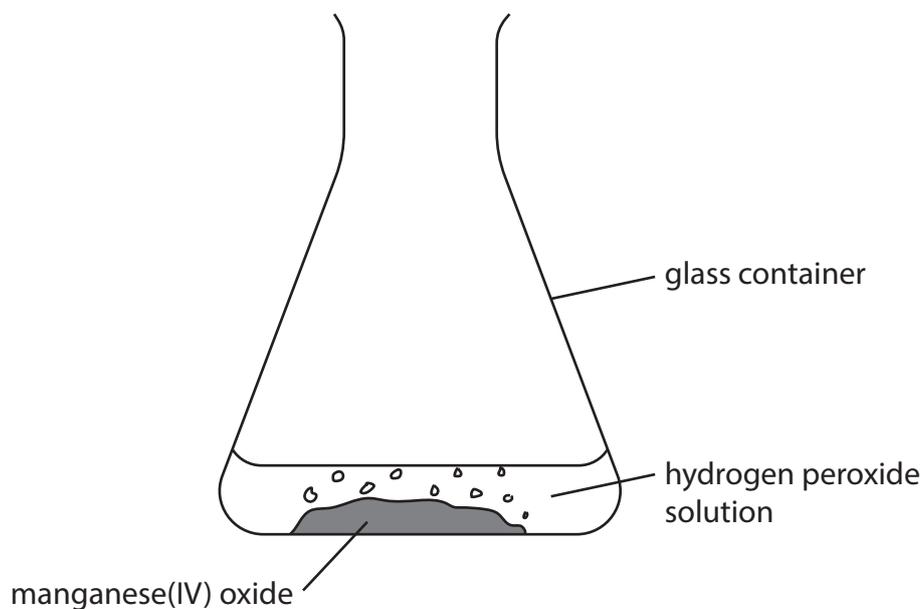
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(b) A student adds 50 cm³ of hydrogen peroxide solution to a glass container and then adds 1.0 g of manganese(IV) oxide.

The diagram shows the apparatus the student uses.



(i) Name the glass container the student uses.

(1)

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- (ii) The student waits until the hydrogen peroxide solution completely decomposes.

Describe how the student could then show that the manganese(IV) oxide was a catalyst and not a reactant.

(3)

(Total for Question 10 = 6 marks)

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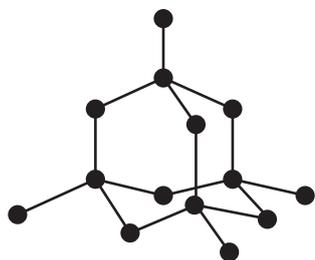


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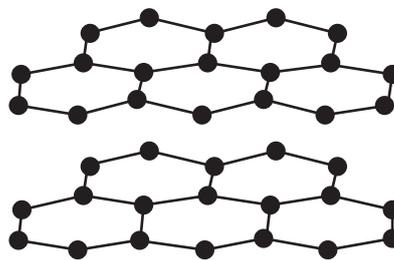
11 Diamond and graphite are both forms of the element carbon.

Diamond and graphite both have covalent bonds and giant covalent structures.

The diagram represents the structure of diamond and the structure of graphite.



diamond



graphite

(a) Give a reason why diamond is an element.

(1)

(b) Describe the forces of attraction in a covalent bond.

(2)

(c) (i) Explain why graphite conducts electricity.

(2)

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(ii) Explain why diamond is hard but graphite is soft.

(4)

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(d) Another form of carbon has molecules with the formula C_x
 x represents the number of carbon atoms in each molecule.

Each molecule of C_x has a mass of 1.40×10^{-21} g.

One mole of C_x contains 6.02×10^{23} molecules.

Calculate the M_r of C_x and the value of x

[for carbon, $A_r = 12$]

(3)

$M_r =$

$x =$

(Total for Question 11 = 12 marks)

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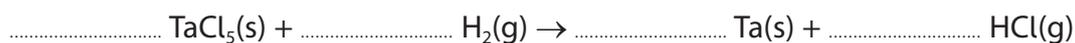
12 This question is about the metal tantalum, Ta.

Tantalum metal can be produced by heating tantalum chloride (TaCl_5) and hydrogen gas in a furnace.

The other product of the reaction is hydrogen chloride.

(a) Complete the equation for the reaction.

(1)



(b) As tantalum chloride is heated, the mass of solid in the furnace decreases leaving tantalum as the only solid product.

The table shows the mass of solid in the furnace at one-hour intervals.

Time in hours	Mass of solid in the furnace in kg
0	2510
1	2207
2	1960
3	1506
4	1329
5	1267
6	1267
7	1267

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(i) State how the data in the table shows that the reaction is complete.

(1)

(ii) Use the data to show that the formula of tantalum chloride is TaCl_5

[for tantalum, $A_r = 181$ for chlorine, $A_r = 35.5$]

(3)

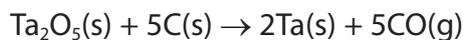
QUESTION 12 CONTINUES ON NEXT PAGE.



P 7 3 4 2 4 A 0 3 1 3 2

- (c) Another method of extracting tantalum is by reacting tantalum(V) oxide with carbon.

This is the equation for the reaction.



- (i) Explain why this is a redox reaction.

(2)

- (ii) 2000 mol of tantalum(V) oxide is heated with 500 000 g of carbon.

Show by calculation that the carbon is in excess.

[for carbon, $A_r = 12$]

(2)

- (iii) Calculate the maximum mass, in grams, of tantalum that can be obtained from 2000 mol of tantalum(V) oxide.

[for tantalum, $A_r = 181$]

(2)

mass = g

(Total for Question 12 = 11 marks)

TOTAL FOR PAPER = 110 MARKS

