



Established in 1879

Raffles Girls' School

(SECONDARY)

Name: _____

Class: _____

Register No: _____

CHEMISTRY YEAR FOUR End-of-Year Assessment

Tuesday

5 October 2021

2 hours

INSTRUCTIONS TO CANDIDATES

Write your name and register number in the spaces provided.
Write in dark blue or black ink.

For **Section A**, indicate your answers on the separate Answer Sheet provided.

Answer all other questions in the space provided.

All quantitative answers should include appropriate units.

The use of an approved scientific calculator is expected, where appropriate.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [] at the end of each question or part question.

You may be penalised for incorrect use of units and/or not giving quantitative answers to an appropriate number of significant figures.

A copy of the Periodic Table is provided on the last page of the Question Paper.

The total number of marks for this paper is **80** and the weighting is **40%**.

For examiner's use

Question / Section	Marks Obtained
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Section A / 20

1-20	
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Section B / 60

21	/6
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22	/7
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23	/7
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24	/7
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25	/9
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26	/10
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27	/14
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statement/ units/ sig. fig.	
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Total	/80
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Parent's / Guardian's Name: _____

Signature: _____ Date: _____

Section A – Multiple Choice Questions [20 marks]

Answer all questions. For each question, there are four possible answers (**A**, **B**, **C**, and **D**). Choose the most appropriate answer and record your choice in the separate Answer Sheet provided.

- 1 Which row shows the source and effect of the pollutant?

	pollutant	source	effect
A	carbon monoxide	combustion of fuels	global warming
B	oxides of nitrogen	lightning	irritates eyes and lungs
C	sulfur dioxide	acid rain	volcanic eruptions
D	unburnt hydrocarbon	decay of plant matter	acid rain

- 2 Which pair of reagents is most suitable to prepare copper(II) chloride?

- A** copper and dilute hydrochloric acid
B copper(II) hydroxide and dilute hydrochloric acid
C copper(II) nitrate solution and dilute hydrochloric acid
D copper(II) sulfate solution and sodium chloride solution

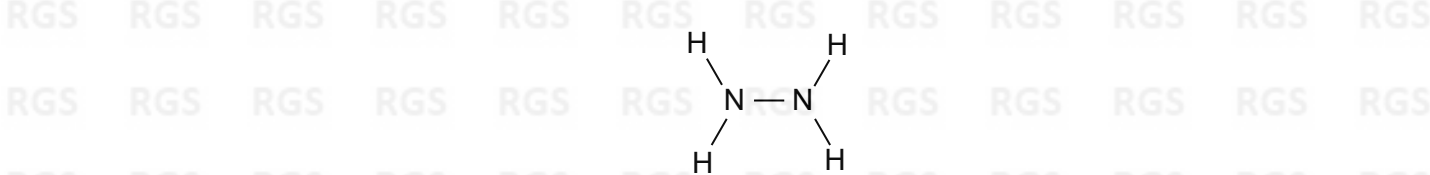
- 3 The table provides information about the electrical conductivity of four substances.

substance	electrical conductivity		
	in solid state	in molten state	in aqueous state
W	no	no	no
X	yes	yes	no
Y	no	yes	yes
Z	no	no	yes

Which row is correct?

	W	X	Y	Z
A	copper	citric acid	diamond	sodium chloride
B	citric acid	sodium chloride	copper	diamond
C	diamond	copper	sodium chloride	citric acid
D	sodium chloride	diamond	citric acid	copper

4 The structural formula of hydrazine, N_2H_4 , is given below.



What is the total number of electrons involved in bonding?

- | | |
|---|----|
| A | 5 |
| B | 6 |
| C | 10 |
| D | 14 |

5 The diagram shows part of the Periodic Table.

[illegible]

Which statement is correct?

- A** T is denser than U.
B Q is more reactive than S.
C P has a lower melting point than T.
D R has less metallic character than S.

6 Which equation represents an endothermic reaction?

- A** $\text{C(s)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$
- B** $\text{CaCO}_3\text{(s)} \rightarrow \text{CaO(s)} + \text{CO}_2\text{(g)}$
- C** $\text{Zn(s)} + \text{CuSO}_4\text{(aq)} \rightarrow \text{ZnSO}_4\text{(aq)} + \text{Cu(s)}$
- D** $\text{HCl(aq)} + \text{NaOH(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$

7 Which statement is correct about the Haber process?

- A Increasing the pressure speeds up the reaction.
- B Hydrogen is obtained from the fractional distillation of air.
- C A high yield of ammonia is favoured by high temperature.
- D Magnesium catalyst is used to increase the production of ammonia.

8 A molecule of hydrocarbon $C_{12}H_{26}$ undergoes cracking to produce one hexane molecule and a number of ethene molecules. How many ethene molecules are produced?

- A 1
- B 2
- C 3
- D 4

9 Gas pressure is one of the factors affecting the rate of reaction.

Which reaction is not affected by changes in pressure?

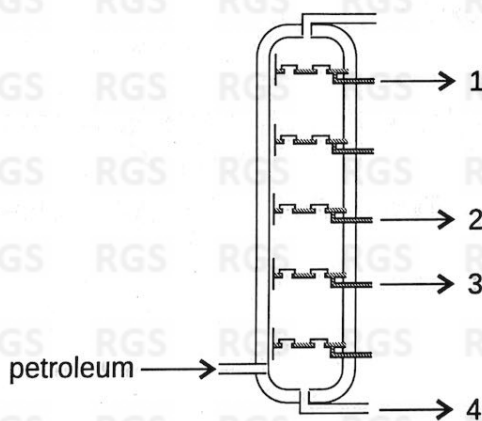
- A $CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$
- B $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$
- C $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$
- D $CO_2(g) + Ca(OH)_2(aq) \rightarrow CaCO_3(s) + H_2O(l)$

10 Ferrites are compounds that consist of iron oxide and one other metal. One such ferrite contains 18.5% calcium and 51.9% iron by mass.

What is the empirical formula of the ferrite?

- A $CaFe_2O$
- B $CaFe_2O_4$
- C Ca_2FeO_2
- D Ca_4Fe_2O

- 11 The diagram shows the fractional distillation of petroleum.



Which row shows the fractions obtained?

	1	2	3	4
A	bitumen	diesel	kerosene	petrol
B	kerosene	petrol	bitumen	diesel
C	petrol	kerosene	diesel	bitumen
D	diesel	bitumen	petrol	kerosene

- 12 In what way is ammonia separated from the reaction mixture when it is produced during the Haber Process?

- A** by dissolving the reactants
- B** by cooling the reaction mixture
- C** by filtering out the reactants using cotton wool
- D** by passing the reaction mixture through fused calcium oxide

- 13 A 14.0 g sample of nitrogen gas contains the same number of atoms as 23.0 g of element Z which is monoatomic.

What is the relative atomic mass of Z?

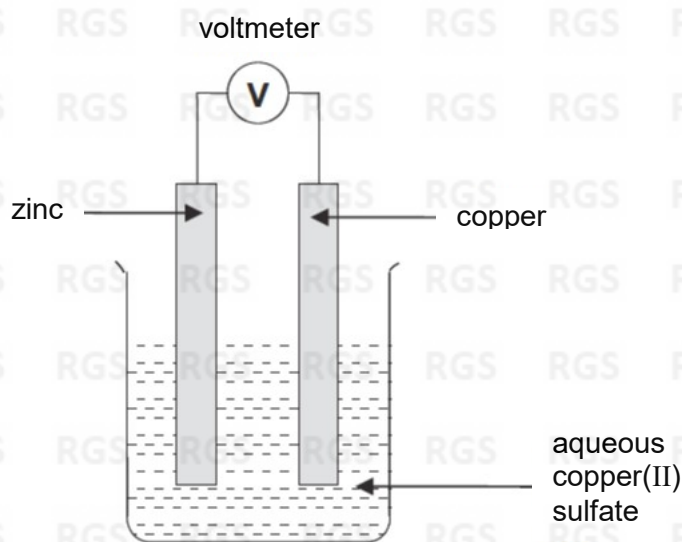
- A** 7
- B** 14
- C** 23
- D** 46

- 14** Galvanising is a method used to coat the surface of iron with a layer of zinc or tin to prevent rusting.

Which statement explains why zinc is a better choice than tin?

- A** Zinc has a lower density than tin.
- B** Zinc is more readily reduced than tin.
- C** Zinc loses electrons more readily than tin.
- D** Zinc has a lower relative atomic mass than tin.

- 15** The diagram shows a simple cell.



Which statement is correct?

- A** Zinc oxidises and becomes smaller.
- B** Copper oxidises and becomes smaller.
- C** Effervescence of hydrogen gas is observed at the zinc electrode.
- D** Effervescence of oxygen gas is observed at the copper electrode.

- The table shows the observation seen.

solution number	potassium iodide	potassium manganate(VII)
1	colourless to brown	purple to colourless
2	colourless to brown	no observable change
3	no observable change	purple to colourless
4	no observable change	no observable change

A 3 only

C 1 and 3 only

B 1 and 2 only

D 2 and 4 only

- A 2

B 3

C 4

D 5

- 75 g of the fat reacts with 120 g aqueous bromine.

How many carbon-carbon double bonds are there in each molecule of fat?

A 2

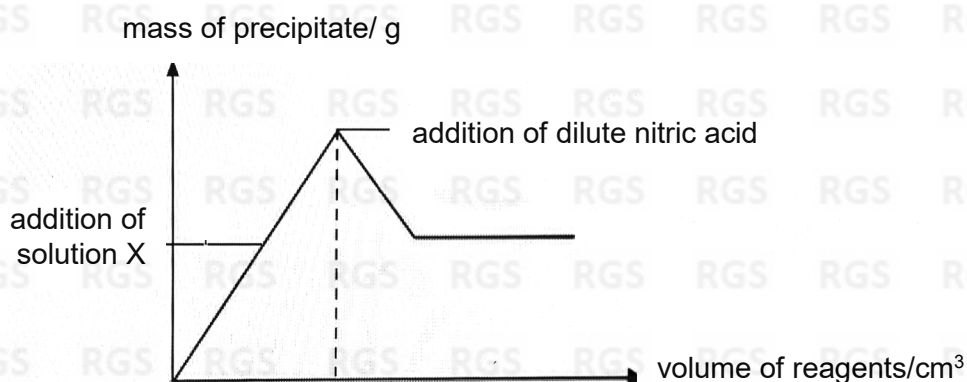
B 3

C 4

D 6

- 19 Solution X is gradually added to solution Y, followed by addition of dilute nitric acid.

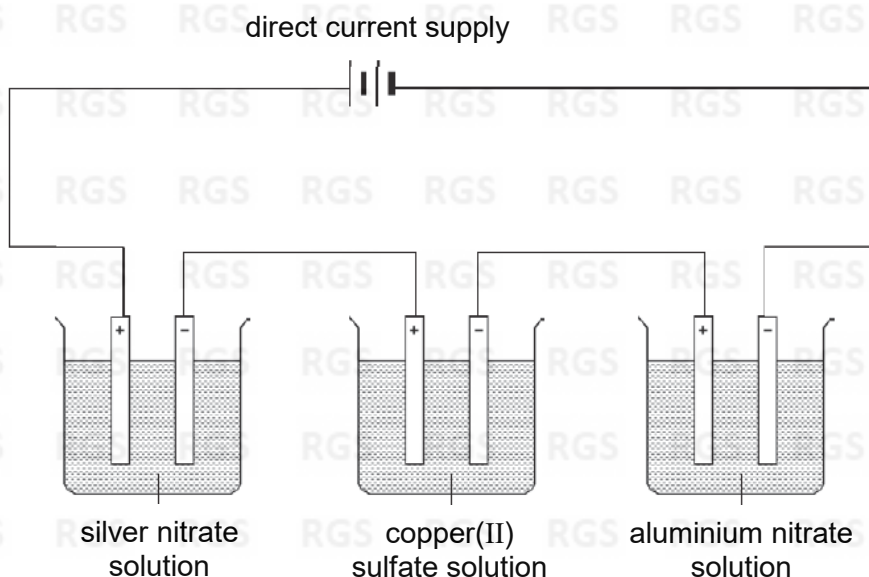
The graph shows the change in mass of precipitate formed.



Which row is correct?

	solution X	anions present in solution Y
A	aqueous barium nitrate	chloride, carbonate
B	aqueous barium nitrate	iodide, sulfate
C	aqueous silver nitrate	chloride, carbonate
D	aqueous silver nitrate	iodide, sulfate

- 20** The diagram shows a set up with three electrolytic cells. Carbon electrodes are used and the respective electrolytes are shown. 0.500 mol of electrons flows through the circuit in the first minute.



Which row shows the masses of metals deposited at the cathodes at the end of one minute?

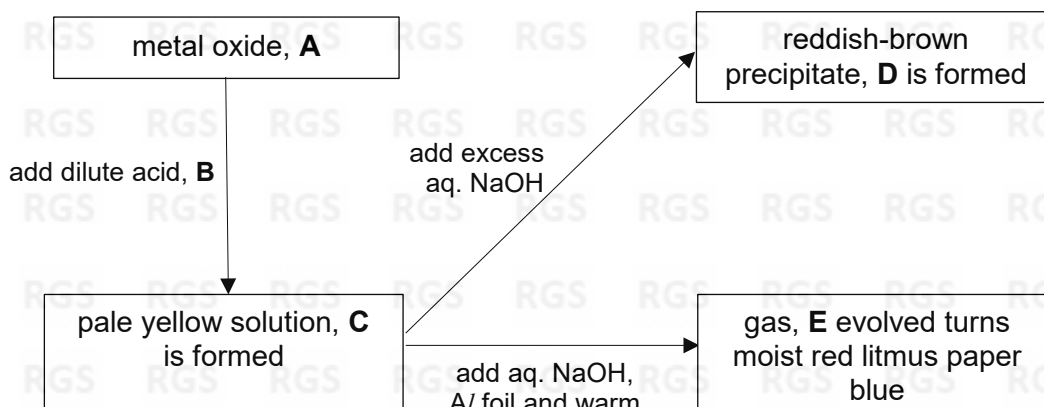
	mass of silver /g	mass of copper /g	mass of aluminium /g
A	54.0	16.0	0.0
B	54.0	16.0	27.0
C	108.0	64.0	0.00
D	108.0	64.0	27.0

----- End of Section A -----

Section B – Structured Questions [60 Marks]

Answer **ALL** questions and write your answers in the spaces provided.

- 21** The diagram below shows the reaction scheme of an insoluble metal oxide, **A**, which undergoes a series of reactions.



- (a) Identify the substances below.

A

B

C

D

E [5]

- (b) Write an ionic equation to show the reaction between **A** and **B**.

..... [1]

[Total: 6]

22 **X** belongs to Group I in the Periodic Table.

(a) Give **two** physical properties of **X**.

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

(b) A piece of **X** is added to cold water containing a few drops of Universal Indicator solution.

(i) Write a chemical equation, including state symbols, for the reaction.

..... [2]

(ii) State the colour change observed in the reaction.

..... [1]

(c) **X** is below sodium in Group I of the Periodic Table.

State and explain the differences in their reactivities in cold water.

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

[Total: 7]

23 The table below shows some information about three hydrogen halides.

hydrogen halide	relative molecular mass, M_r	melting point / °C	boiling point / °C
hydrogen chloride	36.5	– 114	– 85.1
hydrogen bromide	81.0	– 86.9	– 66.8
hydrogen iodide	128	– 50.8	– 35.4

- (a) Draw a 'dot-and-cross' diagram to show the arrangement of outer shell electrons in hydrogen chloride.

[1]

- (b) State and explain, in terms of bonding, the general trend in melting point of hydrogen halides.

[3]

- (c) Hydrogen halides are soluble in water. When dissolved in water, hydrogen halides dissociate to form hydrogen and halide ions.

hydrogen halide	bond energy/ kJ mol^{-1}	name of acid formed
HCl	431	hydrochloric acid
HBr	366	hydrobromic acid
HI	299	hydroiodic acid

The larger the extent of dissociation of the hydrogen halide molecule, the stronger the acid.

Using the data provided, state and explain which of the three acids is the strongest.

RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS

RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS

RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS

RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS

[3]

[Total: 7]

24 Propane is a highly flammable gas.

The equation for the complete combustion of propane is shown below.



The table below shows the bond energies of some chemical bonds.

bond	bond energy (kJ/mol)
C – H	413
C – C	348
C = O	799
O – H	463
O = O	495

(a) Calculate the enthalpy change for the combustion of 1 mole of propane.

[3]

(b) Explain, in terms of bond breaking and bond forming, why the reaction is exothermic.

.....

.....

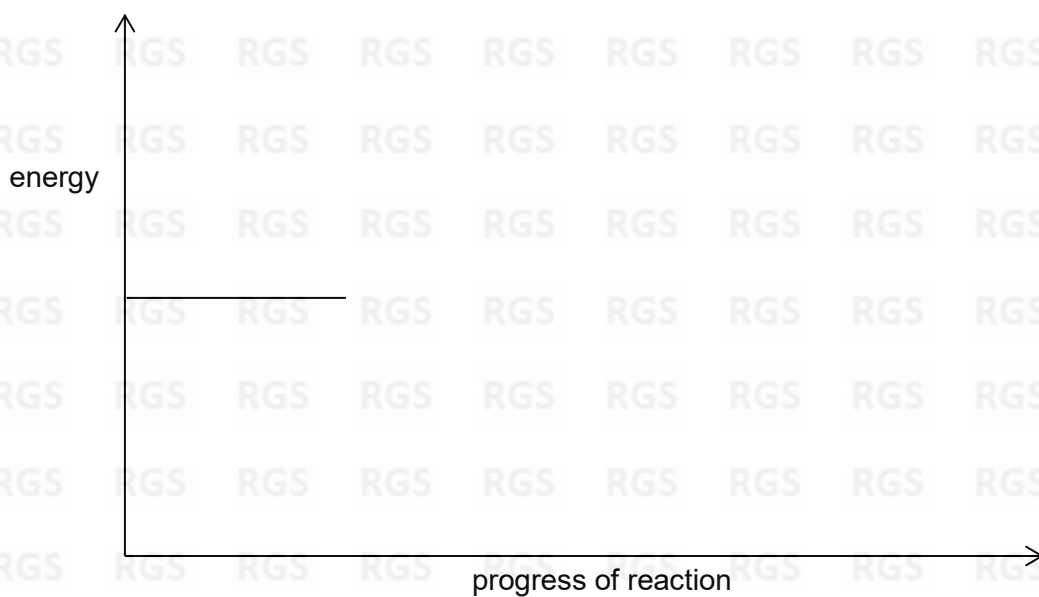
.....

[2]

(c) Complete the energy profile diagram for the complete combustion of propane.

Your diagram should include:

- the identities of the reactants and products of the reaction, and
- labels to show the enthalpy change of reaction and the activation energy.



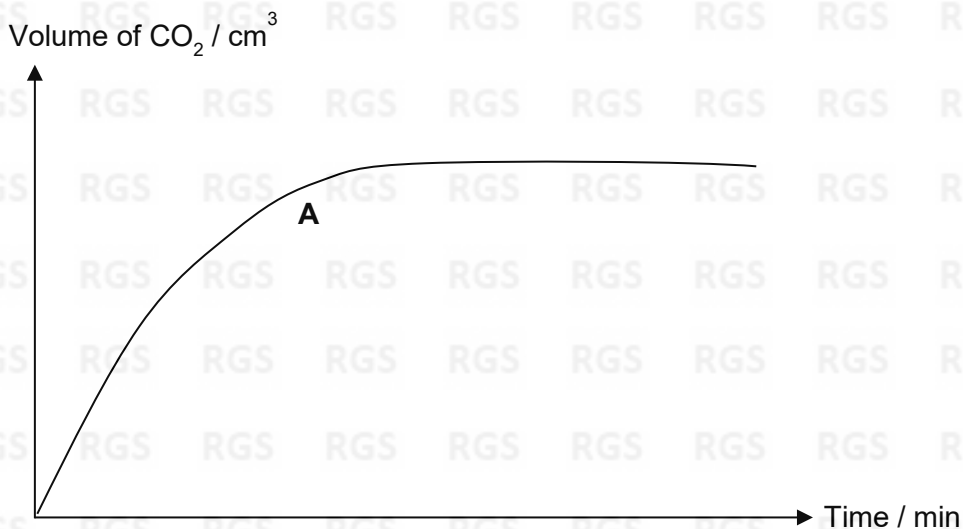
[2]

[Total: 7]

- 25** A student investigated the rate of reaction between calcium carbonate and hydrochloric acid.

Experiment **A**: 20.0 cm³ of 1.0 mol/dm³ of hydrochloric acid reacted with an excess of large lumps of calcium carbonate at room temperature.

The results of the experiment is shown in the graph.



- (a)** Explain what is meant by 'effective collision' in a chemical reaction.

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

- (b)** A further experiment was carried out where the temperature was raised to 50 °C.

Explain, using collision theory, how this will affect the rate of reaction.

.....
.....
.....
.....
..... [3]

- (c) Two further experiments were carried out.

Experiment **B**: 20.0 cm³ of 0.5 mol/dm³ of hydrochloric acid reacted with an excess of large lumps of calcium carbonate at room temperature

Experiment **C**: 20.0 cm³ of 1.0 mol/dm³ of hydrochloric acid reacted with an excess of powdered calcium carbonate at room temperature

Sketch and label the results of these experiments on the graph. [2]

- (d) A student repeated Experiment **A** using 20.0 cm³ of 1.0 mol/dm³ of sulfuric acid. She observed that the initial reaction appeared faster than in Experiment **A**, but did not reach completion.

Explain her observations.

.....
.....

.....

..... [2]

[Total: 9]

26 (a) When 10.0 cm^3 of a gaseous hydrocarbon C_xH_y reacted with excess oxygen, 60.0 cm^3 of gases and 0.0375 g of water was collected. After bubbling the products into excess aqueous sodium hydroxide, only 20.0 cm^3 of gas was collected. All volumes were measured at room temperature and pressure.

- (i) Explain why there is a decrease in the volume of gases collected after bubbling the products into excess aqueous sodium hydroxide.

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

- (ii) Calculate the mole ratio $\text{C}_x\text{H}_y : \text{CO}_2 : \text{H}_2\text{O}$ in the reaction.

..... [3]

- (iii) Hence, deduce the molecular formula of the hydrocarbon.

..... [1]

- (b) Octane can be 'cracked' to produce butene which can then be separated by fractional distillation.

- (i) State the conditions necessary for this reaction to take place.

..... [1]

- (ii) Draw and name the full structural formulae of the product obtained when but-1-ene reacts with steam and aqueous chlorine respectively.

product of but-1-ene with steam	product of but-1-ene with aqueous chlorine
full structural formula:	full structural formula:
name:	name:

RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS RGS [4]

[Total: 10]

- 27 (a)** Standard electrode potentials (E°) are also known as reduction potentials. They measure how easily a substance is reduced.

The E° values for some substances are shown below.

$\text{Ag}^+(\text{aq}) + \text{e} \rightleftharpoons \text{Ag}(\text{s})$	$E^\circ = +0.80 \text{ V}$
$\text{Ba}^{2+}(\text{aq}) + 2\text{e} \rightleftharpoons \text{Ba}(\text{s})$	$E^\circ = -2.90 \text{ V}$
$\text{Co}^{2+}(\text{aq}) + 2\text{e} \rightleftharpoons \text{Co}(\text{s})$	$E^\circ = -0.28 \text{ V}$
$\text{Cu}^{2+}(\text{aq}) + 2\text{e} \rightleftharpoons \text{Cu}(\text{s})$	$E^\circ = +0.34 \text{ V}$
$2\text{H}^+(\text{aq}) + 2\text{e} \rightleftharpoons \text{H}_2(\text{g})$	$E^\circ = 0.00 \text{ V}$
$\text{Mg}^{2+}(\text{aq}) + 2\text{e} \rightleftharpoons \text{Mg}(\text{s})$	$E^\circ = -2.38 \text{ V}$
$\text{Zn}^{2+}(\text{aq}) + 2\text{e} \rightleftharpoons \text{Zn}(\text{s})$	$E^\circ = -0.76 \text{ V}$

The more positive the E° value, the more likely the forward reaction takes place and the more easily the substance is reduced.

Conversely, the more negative the E° value, the more likely the reverse reaction takes place and the more easily the substance is oxidised.

As the reactivity of metals increases, the E° values becomes increasingly negative.

- (i) State the most reactive metal from the list.

..... [1]

- (ii) A piece of zinc metal was added to a colourless solution of barium nitrate in test tube **A** while another piece of zinc metal was added to a pink solution of cobalt(II) nitrate in test tube **B**.

State the observation(s), if any, in the two test tubes and write relevant ionic equation(s) to support your answer.

observations:

.....

.....

ionic equation(s):

..... [3]

- (iii) Will barium carbonate require a higher or lower temperature than cobalt(II) carbonate to decompose?

Explain your answer.

.....

.....

.....

.....

[2]

- (iv) The reactions of two metals **X** and **Y** are given in the table below.

metal X	No visible reaction observed between metal X and acid. Metal X displaces copper from its solution.
metal Y	Hot metal Y reacts readily with steam but not with cold water. Metal Y displaces zinc from its solution.

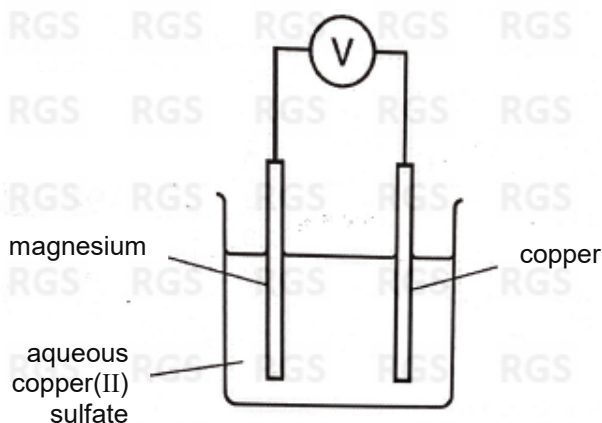
Use the information above to predict the E° values of metals **X** and **Y**.

Metal **X**:

Metal **Y**:

[2]

- (b) The diagram shows a simple cell.



- (i) Write down the ionic half-equations, including state symbols, for the reaction at the electrodes.

cathode:

anode:

[2]

Magnesium metal is replaced with silver and metals **P**, **Q** and **R**. The voltmeter readings for the different setups are as shown below.

metal	voltmeter reading / V
magnesium	+2.72
silver	-0.46
P	+0.48
Q	+0.78
R	-0.70

- (ii) Arrange the metals, copper, magnesium, silver, **P**, **Q** and **R** in increasing order of reactivity.

..... [1]

- (iii) Explain your answer in (ii).

..... [3]

[Total: 14]

----- End of Section B -----

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The Periodic Table of Elements

Group																		
I	II	Key										III	IV	V	VI	VII	0	
		proton (atomic) number atomic symbol name relative atomic mass																
		1 H hydrogen 1																
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	2 He helium 4		
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	57 – 71 lanthanoids	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 -	89 – 103 actinoids	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 -	116 Lv livermorium -	118 Ts tennessine -	119 Og oganesson -	120 Nh nihonium -	121 Lr lawrencium -	
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	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	
actinoids																		
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 -	104 Rf rutherfordium -	105 Db dubnium -	106 Sg seaborgium -	