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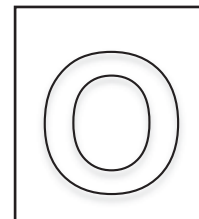


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中正中学 义顺

CHUNG CHENG HIGH SCHOOL (YISHUN)



2020 Preliminary Examination
Secondary Four Express

CANDIDATE
NAME

CLASS

INDEX
NUMBER

CHEMISTRY

6092/01

Paper 1

16 September 2020

Additional Materials: OTAS

1 hour

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page and on the OTAS provided. Shade your register number on the OTAS clearly.

Write in soft pencil.

Do not use staples, paper clips, glue, correction fluid or correction tape.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers, **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate OTAS.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

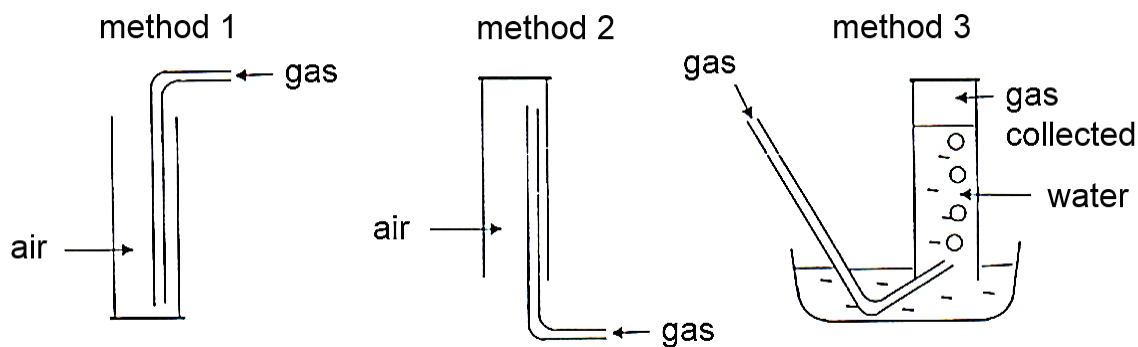
Any rough working should be done in this booklet.

A copy of the Periodic Table is printed on page **18**.

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

Setter: Mdm. Tay Hui Cheng

1 The following diagrams show three methods commonly used to collect gases.



What is the best method for collecting ammonia, chlorine, hydrogen and oxygen?

	ammonia	chlorine	hydrogen	oxygen
A	2	3	2	1
B	1	2	3	3
C	3	1	2	2
D	2	1	3	3

2 Some students are asked to describe the difference between the particles in gases and liquids.

Three of their suggestions are:

- 1 Particles in gases are further apart than particles in liquids.
- 2 Particles in gases are bigger than particles in liquids.
- 3 Particles in gases are smaller than particles in liquids.

Which suggestion or suggestions are correct?

- A** 1 only **B** 2 only **C** 3 only **D** 1, 2 and 3

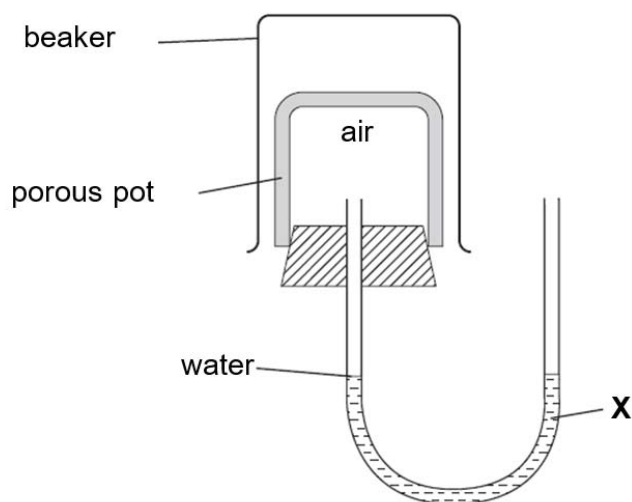
3 The properties of five different substances are shown in the table below.

substance	melting point / °C	boiling point / °C
P	50	80
Q	70	500
R	65	67
S	-15	-12
T	0	99

At which temperature would two liquids exist?

- A -20°C B -15°C C 15°C D 85°C

4 The apparatus shown in the diagram was set up.



Which gas, when present in the beaker, will cause the water level at X to fall?

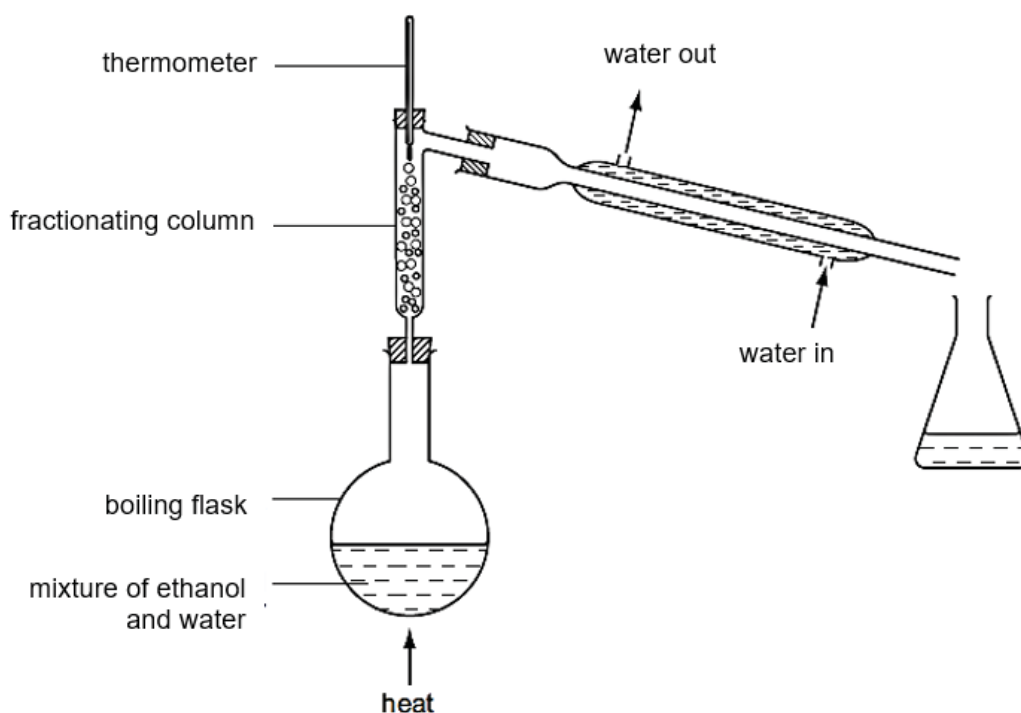
- A ammonia, NH₃ B carbon dioxide, CO₂
C carbon monoxide, CO D nitrogen, N₂

5 How many of the following physical processes could be used to separate a mixture of petrol and water?

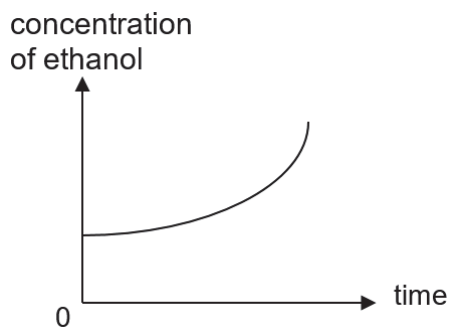
- 1 distillation
- 2 filtration
- 3 sublimation
- 4 use of a separating funnel

- A 0 B 1 C 2 D 3

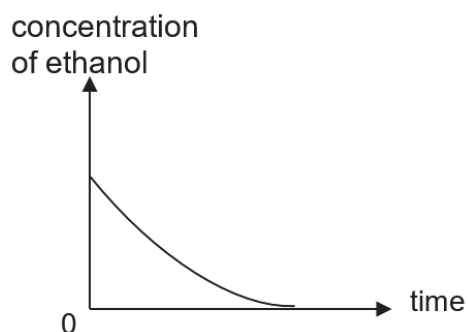
- 6 Fractional distillation is used to distil ethanol (boiling point 78°C) from a dilute ethanol solution.



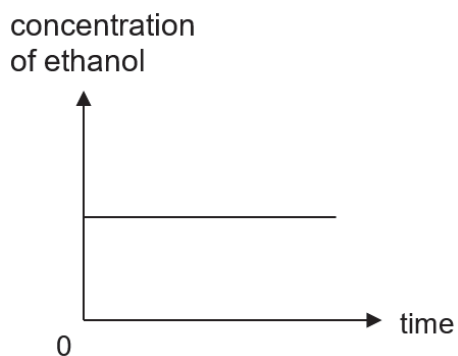
Which one of the following graphs best shows the change in concentration of ethanol in the boiling flask as distillation proceeds?



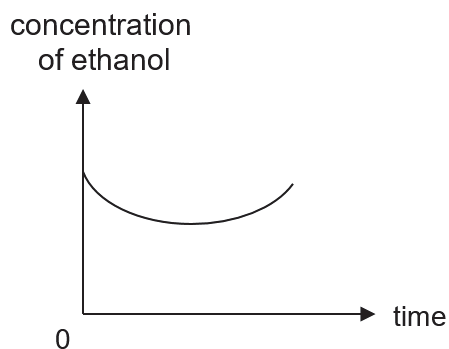
A



B

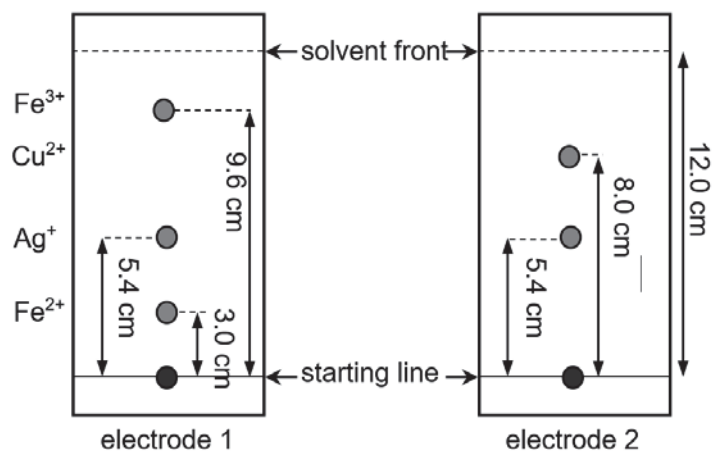


C



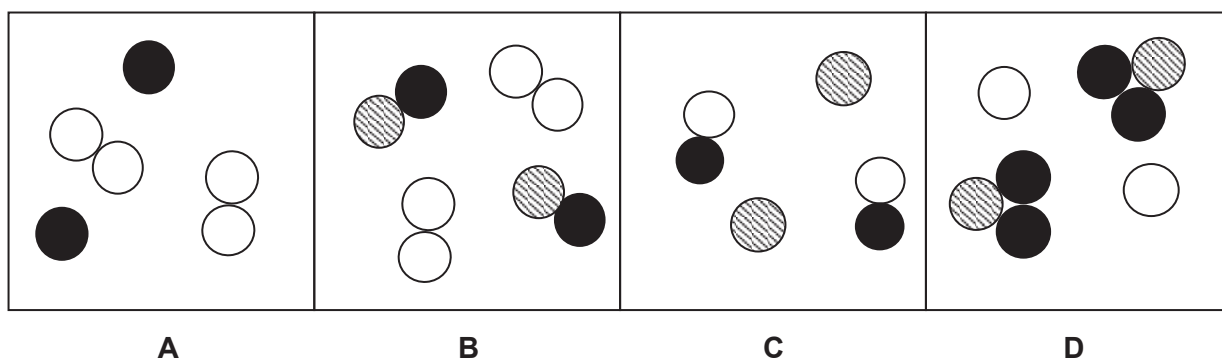
D

- 7 Chromatography was used to compare the impurities in the electrodes of two lead-acid type batteries. The chromatogram was sprayed with a locating agent and the results are shown below:



Which ion has the R_f value of 0.8?

- A Fe^{3+} B Cu^{2+} C Ag^+ D Fe^{2+}
- 8 Which diagram best represents a mixture of neon and hydrogen bromide?



- 9 At which temperatures does seawater start to freeze and boil?

	start to freeze at	start to boil at
A	2°C	101°C
B	2°C	99°C
C	-2°C	101°C
D	-2°C	99°C

10 Some properties of four substances **P**, **Q**, **R** and **S** are given in the table below.

substance	percentage composition by mass	electrical conductivity when solid	effect of heat
P	constant	yes	solid burns in air to form an oxide
Q	varies	no	liquid burns to form carbon dioxide and water
R	constant	no	solid decomposes to form two products
S	varies	yes	solid melts

Which classification of the substances as an element, a mixture or a compound is correct?

	element	mixture	compound
A	P	S	Q, R
B	S	Q, R	P
C	R	S	Q, P
D	P	Q, S	R

11 An ion L^{3-} has 18 electrons. If its nucleon number is 31, what is the composition of its nucleus?

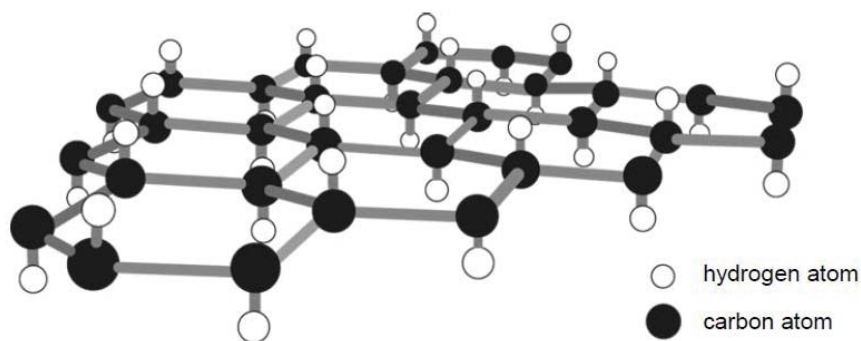
- A** 15 protons and 15 neutrons
- B** 15 protons and 16 neutrons
- C** 18 protons and 13 neutrons
- D** 21 protons and 10 neutrons

12 Hydrogen can form both H^+ ions and H^- ions.

Which statement about these two ions is **correct**?

- A** A H^+ ion has no electrons in its first shell.
- B** A H^+ ion has more protons than a H^- ion.
- C** A H^- ion has one more electron than a H^+ ion.
- D** A H^- ion is formed when a hydrogen atom loses an electron.

- 16 Graphane, an allotrope of carbon has a similar structure to graphite, except that, it has one hydrogen atom attached to each carbon as shown in the diagram.



Which set of properties will graphane have?

- 1 It is soft.
- 2 It has a giant molecular structure.
- 3 It conducts electricity in the solid state.

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

- 17 A mixture of ammonia and oxygen was passed over heated platinum. Nitrogen and water were formed.



What are the values of **w**, **x**, **y** and **z** in the above equation?

	w	x	y	z
A	2	2	1	4
B	2	3	1	3
C	4	3	2	6
D	4	2	2	6

18 A student writes down four statements about two gases, hydrogen chloride and carbon dioxide.

- 1 One mole of each gas has the same mass.
- 2 One mole of each gas occupies the same volume at room temperature and pressure.
- 3 One mole of each gas has the same number of atoms.
- 4 One mole of each gas has the same number of molecules.

Which statements are correct?

- A** 1 and 3 only **B** 2 and 4 only
C 1, 2 and 3 only **D** 1, 2 and 4 only

19 The complex $[\text{Ag}(\text{NH}_3)_x]^+$ consists of 76% by mass of silver.

What is the value of x ?

- A** 5 **B** 4 **C** 3 **D** 2

20 The formula of an oxide of element **Y** is Y_3O_4 .

10 g of Y_3O_4 contains 3 g of **Y**.

How many moles of **Y** does 3 g of the element contain?

- A** $\frac{7}{16} \times \frac{3}{4}$ **B** $\frac{7}{16} \times \frac{4}{3}$
C $\frac{10}{16} \times \frac{3}{4}$ **D** $\frac{10}{16} \times \frac{4}{3}$

21 When solid sodium hydrogencarbonate ($M_r = 84$) is heated strongly, the following reaction occurs.



What is the loss in mass when 25.2 g of solid sodium hydrogencarbonate is heated?

- A** 2.7 g **B** 9.3 g **C** 15.9 g **D** 18.6 g

- 22** 20 cm³ of aqueous 0.50 mol/dm³ sulfuric acid exactly neutralised 25 cm³ of an aqueous hydroxide solution of metal **R**. The concentration of the hydroxide solution was 0.80 mol/dm³.

What is the formula of the salt formed?

- A** RSO₄ **B** R(SO₄)₂ **C** R₂SO₄ **D** R₂(SO₄)₃

- 23** 20 cm³ of hydrogen is reacted with 20 cm³ of oxygen to form a gaseous product.

What are the volumes of gases remaining at the end of the reaction?

[All volumes are measured at room temperature and pressure.]

	volume of hydrogen / cm ³	volume of oxygen / cm ³	volume of product / cm ³
A	0	0	20
B	0	0	40
C	0	10	0
D	10	10	0

- 24** On heating, ammonium nitrate, NH₄NO₃, decomposes to form dinitrogen oxide and water.

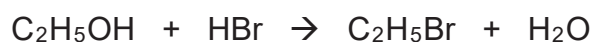


When 90 g of an impure sample of ammonium nitrate is heated, 28 g of water is formed.

What is the percentage purity of ammonium nitrate in the impure sample?

- A** $\frac{28}{18} \times \frac{80}{90} \times 100$ **B** $\frac{28}{36} \times \frac{80}{90} \times 100$
C $\frac{28}{18} \times \frac{90}{80} \times 100$ **D** $\frac{28}{36} \times \frac{90}{80} \times 100$

- 25** In the reaction between 23 g of ethanol, C₂H₅OH, and excess hydrogen bromide, HBr, the mass of bromoethane, C₂H₅Br, obtained is 27 g.



What is the percentage yield of bromoethane?

[M_r: C₂H₅OH, 46; C₂H₅Br, 109]

- A** 25% **B** 50% **C** 60% **D** 75%

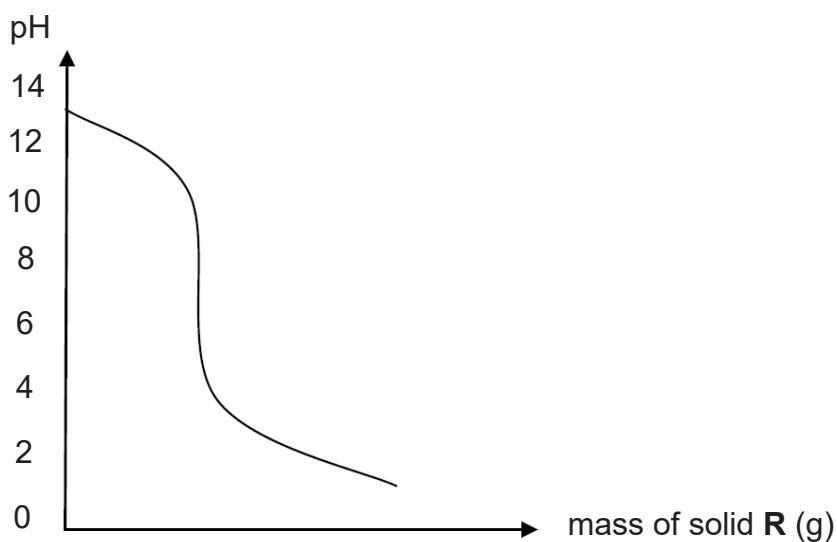
26 The table gives information about three indicators.

indicator	colour change		pH at which colour change takes place
	low pH	high pH	
methyl orange	red	yellow	4.0
bromothymol blue	yellow	blue	6.5
phenolphthalein	colourless	pink	9.0

If equal volumes of these three indicators were mixed, which colour would be observed at pH 5?

- A blue B green C orange D yellow

27 Solid **R** is gradually added to aqueous solution **S**. The changes in pH in solution **S** are shown on the graph.



What are **R** and **S**?

	R	S
A	insoluble metal oxide	nitric acid
B	soluble metal oxide	hydrochloric acid
C	soluble non-metal oxide	aqueous ammonia
D	soluble non-metal oxide	sodium hydroxide

28 Which of the following statements best explains why farmers should not lime the soil and add ammonium nitrate fertiliser at the same time?

- A It is too costly to add both substances together at the same time.
- B The lime makes the soil too alkaline for plant growth.
- C The lime will react with ammonium nitrate and results in the loss of nitrogen.
- D The lime will react with ammonium nitrate to produce acidic substances that inhibit plant growth.

29 How many different sulfates in total could be prepared by the reaction of dilute sulfuric acid with the following substances?

- copper
- magnesium
- silver
- zinc carbonate

A 1 B 2 C 3 D 4

30 A student tested a solution by adding aqueous sodium hydroxide. A precipitate was not seen because the reagent was added too quickly.

What could **not** have been present in the solution?

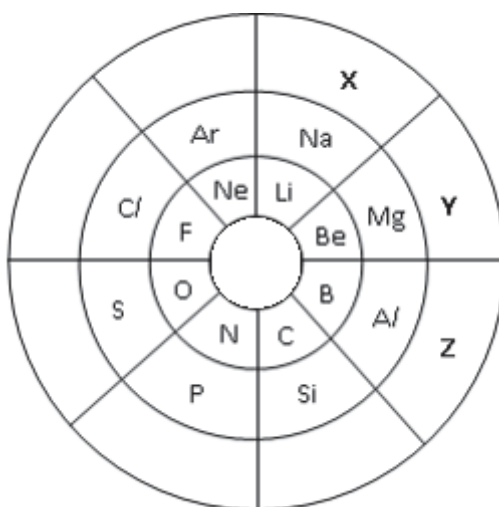
A Al^{3+} B Ca^{2+} C NH_4^+ D Zn^{2+}

31 An excess of aqueous lead(II) nitrate is added to aqueous barium chloride. The precipitate is removed by filtration.

What are the main ions in the filtrate?

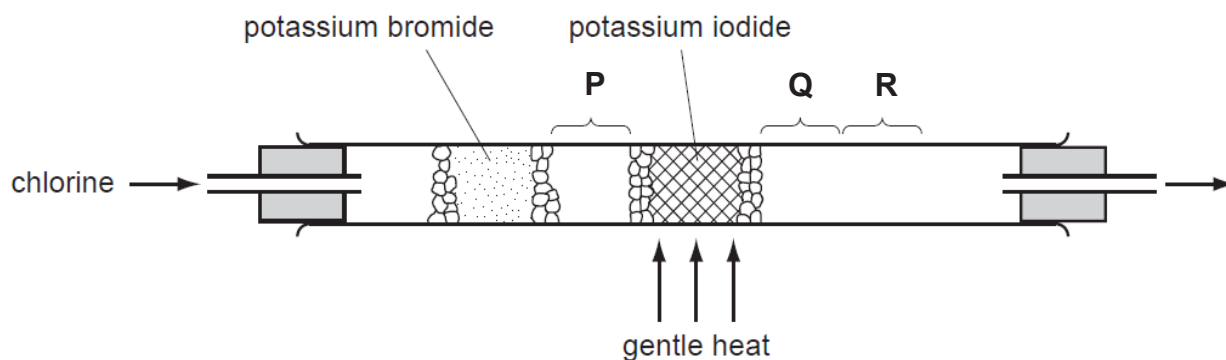
- A Pb^{2+} and NO_3^- only
- B Ba^{2+} and NO_3^- only
- C Ba^{2+} , Cl^- and NO_3^- only
- D Ba^{2+} , Pb^{2+} and NO_3^- only

- 32 Dimitri Mendeleev, a chemist, organised the elements using a system called the Periodic Table. A student suggested another way of arranging the elements as shown below.



Which of the following statements is correct?

- A An atom of **X** contains 3 valence electrons.
 B Elements **X** and **Y** belong to the same group.
 C Element **X** contains more electrons than element **Z**.
 D Elements **X**, **Y** and **Z** belong to the same period.
- 33 Using the apparatus shown, chlorine is passed through the tube.



After a short time, coloured substances are seen at **P**, **Q** and **R**.
 What are these coloured substances?

	P	Q	R
A	green gas	red brown vapour	violet vapour
B	green gas	violet vapour	black solid
C	red brown vapour	violet vapour	black solid
D	violet vapour	red brown vapour	red brown vapour

34 A large volume of copper(II) sulfate solution is left in an iron container overnight.

Which statement describes what happens?

- A The solution evaporates completely and some copper(II) sulfate crystals are left behind.
- B The part of the container in contact with the solution is coated with copper.
- C Some fine iron particles are formed in the solution.
- D Atmospheric oxygen reacts with the copper(II) sulfate to give black copper(II) oxide.

35 Equations for reactions of iron and iron compounds are shown.

- 1 $\text{Fe} + 2\text{HCl} \rightarrow \text{FeCl}_2 + \text{H}_2$
- 2 $2\text{FeCl}_2 + \text{Cl}_2 \rightarrow 2\text{FeCl}_3$
- 3 $\text{FeSO}_4 + \text{Mg} \rightarrow \text{Fe} + \text{MgSO}_4$
- 4 $\text{FeSO}_4 + 2\text{NaOH} \rightarrow \text{Fe(OH)}_2 + \text{Na}_2\text{SO}_4$

How many of these are redox reactions?

- A 1 B 2 C 3 D 4

36 Three different electrochemical cells each containing two of the metals **G**, **H** and **J** are immersed in aqueous potassium nitrate solution. The table below shows the voltage and the positive terminal of each electrochemical cell.

electrochemical cell	metals used	voltage /V	positive terminal
1	G and J	+2.70	J
2	G and H	+1.10	H
3	H and J	+1.60	J

What is the order of **decreasing** reducing power of the metals **G**, **H** and **J**?

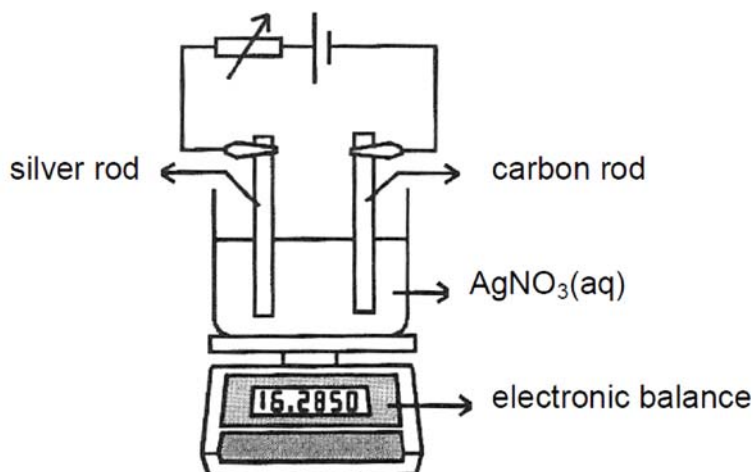
- A **J > H > G** B **H > J > G**
C **G > H > J** D **G > J > H**

37 In an electrolysis experiment, the same amount of charge deposited 54.0 g of silver and 6.4 g of vanadium.

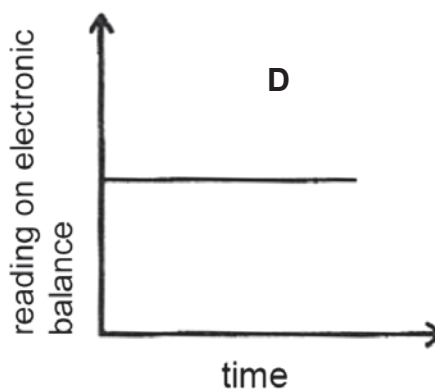
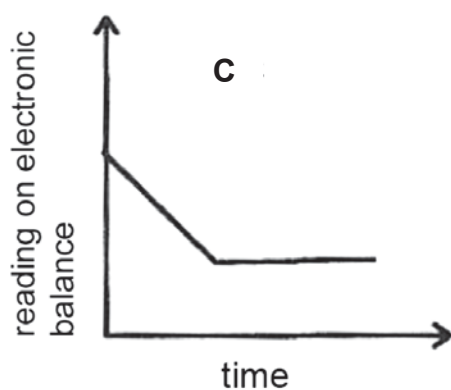
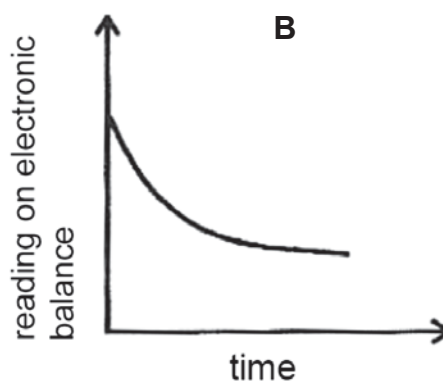
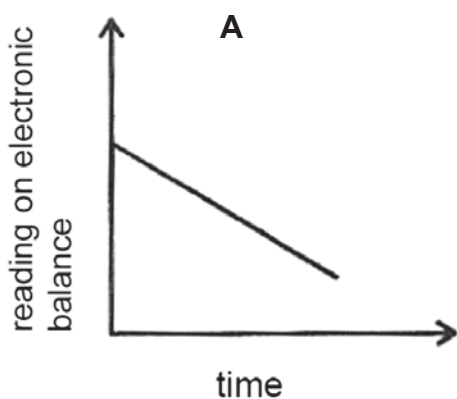
What is the charge on the vanadium ion?

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

- 38 The electrolysis of a 0.5 mol/dm^3 silver nitrate solution was carried out using the following set-up.



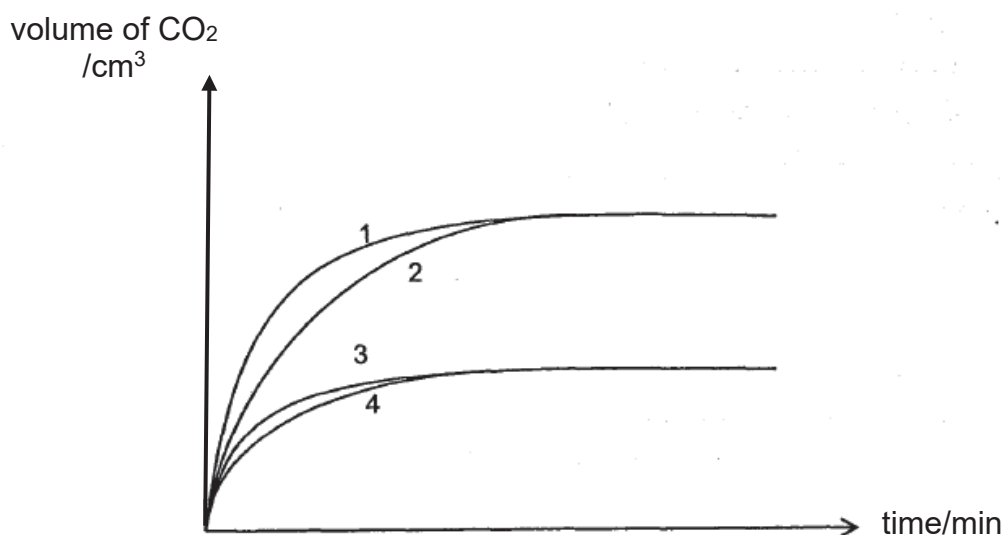
Which of the following graphs best describes how the reading on the electronic balance changes with time during the reaction?



- 39 Four experiments (1, 2, 3 and 4) were carried out by adding calcium carbonate to excess 1.00 mol/dm^3 hydrochloric acid in four separate beakers. The set of conditions (**R**, **S**, **T** and **U**) for the four experiments are shown in the table below.

set of conditions	mass of calcium carbonate / g	type of calcium carbonate
R	5.0	granular
S	10.0	granular
T	5.0	powder
U	10.0	powder

The total volume of carbon dioxide gas evolved was collected and measured at various times for each experiment. The graphs of the results from the four experiments are shown.



Which of the following matches the graphs of experiments 1, 2, 3 and 4 correctly with the set of conditions **R**, **S**, **T** and **U**?

	R	S	T	U
A	3	2	1	4
B	4	1	3	2
C	3	2	4	1
D	4	2	3	1

- 40** Information in the table shows the concentration, in parts per million (ppm), of pollutants in four different industrial areas.

In which areas are limestone sculptures under the greatest threat of pollution?

	unburnt hydrocarbon emission / ppm	nitrogen dioxide emission / ppm	carbon monoxide emission / ppm
A	23	30	0.03
B	30	32	3.0
C	11	38	0.2
D	21	45	0.01

End of Paper

The Periodic Table of Elements

		Group																																																																													
I	II	III	IV	V	VI	VII	0																																																																								
3 Li lithium 7	4 Be beryllium 9	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	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 -	113 Nh nihonium -	114 Fl flerovium -	115 Lv livermorium -	116 Og oganeson -

1
H
hydrogen
1

Key
proton (atomic) number
atomic symbol
name
relative atomic mass

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 -

lanthanoids

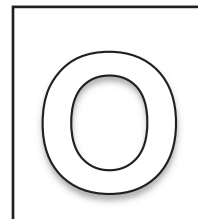
actinoids

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



中正中学 义顺

CHUNG CHENG HIGH SCHOOL (YISHUN)



2020 Preliminary Examination Secondary Four Express

CANDIDATE
NAME

CLASS

INDEX
NUMBER

CHEMISTRY

6092/02

Paper 2

28 August 2020

Additional Materials: NIL

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.

Write in dark blue or black pen.

You are to use a soft pencil for any diagrams or graphs.

Do not use staples, paper clips, glue, correction fluid or correction tape.

Section A (50 marks)

Answer **all** questions in the spaces provided.

Section B (30 marks)

Answer all **three** questions, the last question is in the form either/or.

Answer **all** questions in the spaces provided.

At the end of the paper, fasten all your work securely together.

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

A copy of the Periodic Table is printed on page **20**.

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

For Examiner's Use	
Section A	
Section B	
Total	

Setter: Mdm. Tay Hui Cheng

This document consists of **20** printed pages, INCLUDING the cover page.

[Turn over

Section A (50 marks)

Answer **all** questions in this section.

A1 The table shows the names and symbols of some isotopes of common elements.

isotope name	isotope symbol
chlorine-37	${}^{37}_{17}\text{Cl}$
hydrogen-3	${}^3_1\text{H}$
neon-20	${}^{20}_{10}\text{Ne}$
nitrogen-14	${}^{14}_7\text{N}$
calcium-40	${}^{40}_{20}\text{Ca}$
caesium-131	${}^{131}_{55}\text{Cs}$
barium-137	${}^{137}_{56}\text{Ba}$
iodine-131	${}^{131}_{53}\text{I}$
strontium-88	${}^{88}_{38}\text{Sr}$
neon-34	${}^{34}_{10}\text{Ne}$

Use the isotopes in the table above to answer the following questions.

(a) Give the names of two isotopes that contain the same number of protons in each of their atoms.

..... [1]

(b) Give the names of two isotopes that contain the same number of neutrons in each of their atoms.

..... [1]

(c) Give the names of two isotopes that contain one electron in the outer shells of each of their atoms.

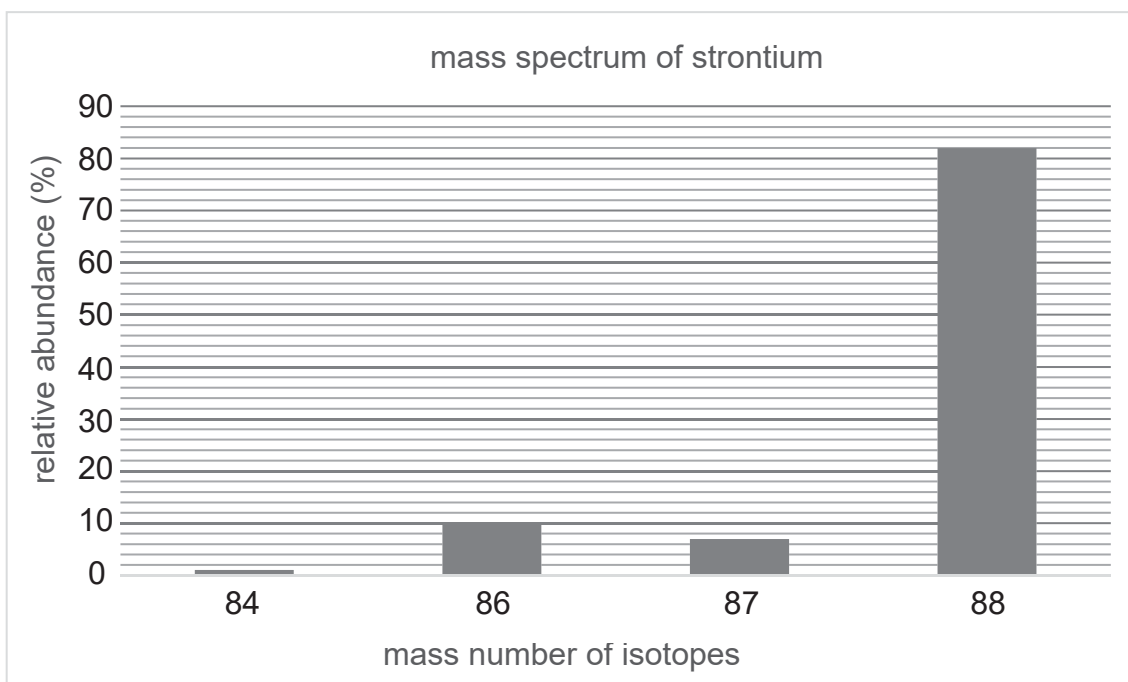
..... [1]

(d) Give the names of two isotopes that have the lowest tendency to form ions.

..... [1]

[4 marks]

- A2** Strontium-88 has three other isotopes and the mass spectrum below shows the relative abundance of each isotopes.



- (a)** Calculate the relative atomic mass of strontium. Leave your answer to 3 significant figures.

[2]

- (b)** 180 g of strontium-88 burns in oxygen to form 245 g of strontium peroxide. Show that the empirical formula of strontium peroxide is SrO_2 .

[2]

(c) The reaction between strontium and oxygen is a redox reaction.



Oxygen acts as an oxidising agent in the reaction.

Use ideas about oxidation state **and** electron transfer to explain why the above statement is true.

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

(d) Strontium also forms strontium superoxide, $\text{Sr}(\text{O}_2)_2$, with oxygen.

Determine the formula for a superoxide ion.

[1]

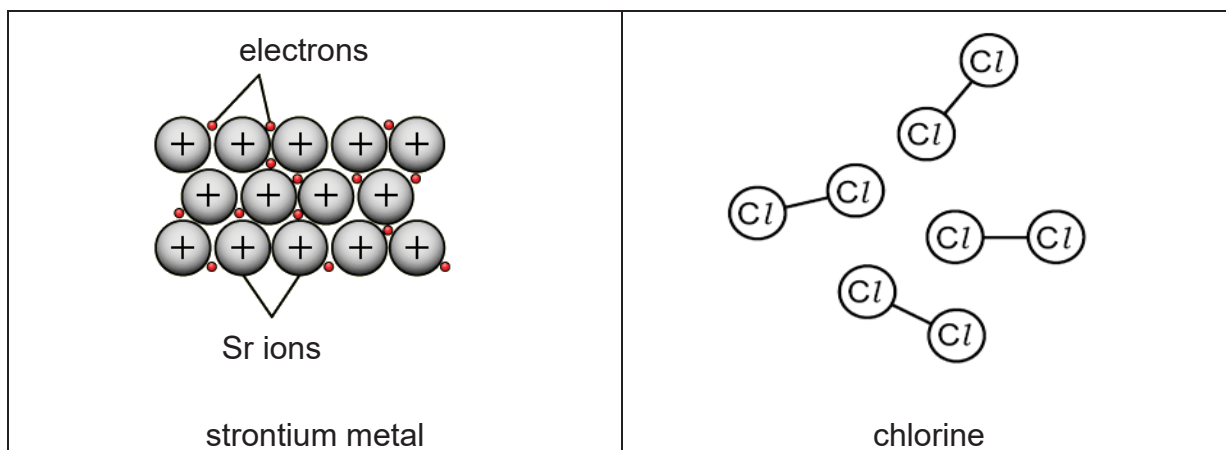
(e) Sodium also forms sodium superoxide with oxygen.

Explain, in terms of bonding, which superoxide, strontium superoxide or sodium superoxide, has a higher melting point.

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

[8 marks]

A3 The particles in strontium and chlorine are shown below.



(a) Describe the **arrangement** of the particles in strontium and chlorine.

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

(b) Use ideas about structure and bonding to explain why the particles are arranged as described in (a).

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

(c) Strontium reacts with chlorine to form strontium chloride which is widely used to reduce hypersensitivity.

Describe what happens when a strontium atom and a chlorine atom react together to form ions.
You may use a diagram in your answer.

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

(d) Alloys of strontium usually consist of added substances.

Explain, with reference to the arrangement of the atoms, how these added substances affects the properties of strontium. You may use diagrams to support your answers.

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

(e) Give reasons why strontium is recycled more often than iron.

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

[10 marks]

A4 The reaction between persulfate ions, $S_2O_8^{2-}$, and iodide ions, I^- , in solution happens in two stages.



(a) Identify the catalyst in the reaction.

..... [1]

(b) Based on the equations given above, write the ionic equation for the uncatalysed reaction between persulfate ions and iodide ions in solution.

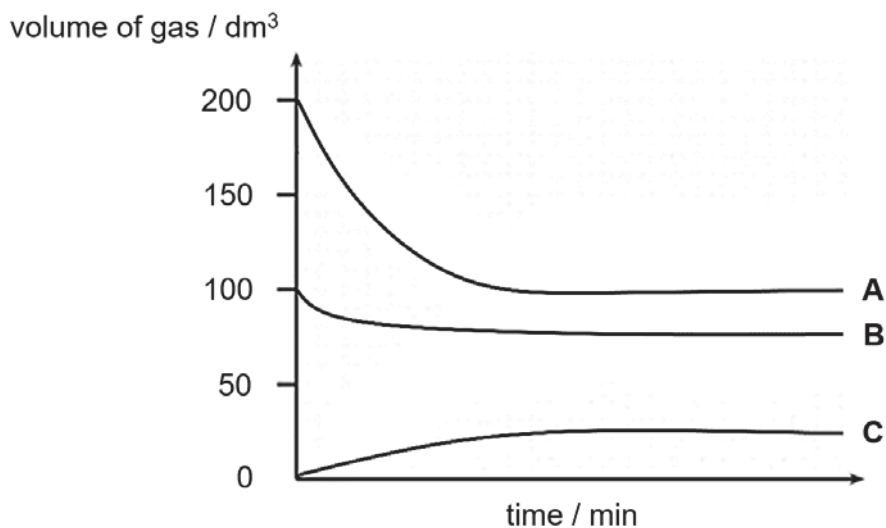
..... [1]

(c) Suggest why magnesium ion **cannot** be used to catalyse the reaction.

..... [1]

[3 marks]

A5 Ammonia is produced in the Haber process. The volume of gases in the reaction chamber is monitored throughout the reaction, and the results were plotted in the graph below.



(a) Write the equation for the formation of ammonia.

..... [1]

(b) Deduce each graph represents which gas, and explain how you derived your answer.

.....

 [2]

(c) A student suggests to mix 15 g of hydrogen with 5 g of nitrogen for complete reaction in the Haber process to form ammonia.

Give **two** reasons why he is **incorrect**.

.....

 [2]

[5 marks]

A6 The table below shows some properties of *oxyacids* of chlorine.

name of acid	chemical formula	reaction with magnesium (all acids have the same concentration)	oxidation state of chlorine
hypochlorous acid	HClO	only a few bubbles seen	
chlorous acid	HClO ₂	reacts readily	
chloric acid	HClO ₃	vigorous	
perchloric acid	HClO ₄	very vigorous	

(a) Suggest why these acids are known as *oxyacids*.

.....
 [2]

(b) Complete the table by filling in the oxidation states of chlorine. [2]

(c) State the relationship between the oxidation state of chlorine in the formula and the strength of the acids.

Explain your reasoning.

.....

 [2]

(d) State which acid will have the highest electrical conductivity.

Explain your answer.

.....
 [2]

(e) Suggest a method, beside observations, the student could use to follow the rate of the reaction.

.....
 [2]

[10 marks]

A7 A student investigated the volume of hydrogen gas produced by electrolysis of water by passing electric current through aqueous solution.

(a) Draw a labelled diagram to show the apparatus he could use.

[2]

(b) Explain why pure water cannot be electrolysed.

.....

..... [1]

(c) Complete the table of information about electrolysis of two aqueous solutions.

solution	name of products of electrolysis		ionic equation for reaction at each electrode
dilute aqueous sodium chloride	at negative electrode		
	at positive electrode		
concentrated aqueous sodium chloride	at negative electrode		
	at positive electrode		

[3]

(d) Use your equations in **(c)** to explain which aqueous solution can be used to electrolyse water.

.....

..... [2]

(e) Explain how the composition of the solution in **(d)** changes after the electrolysis has been running for some time.

.....

.....

..... [2]

[10 marks]

Section B (30 marks)

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B1 Solubility

Ionic compounds are generally soluble in water, such as sodium chloride, NaCl . Some ionic solids such as silver chloride, AgCl , are only sparingly soluble (soluble to a small extent) in water.

The solubility of ionic compounds depends on two factors.

- 1 The forces of attraction between the water molecules and the ions of the solid;
- 2 The forces of attraction between the cations and anions of the solid.

If factor 1 is greater than factor 2, the ionic compound will dissolve in water.

Figure B1.1 shows what happens when sodium chloride dissolves in water.

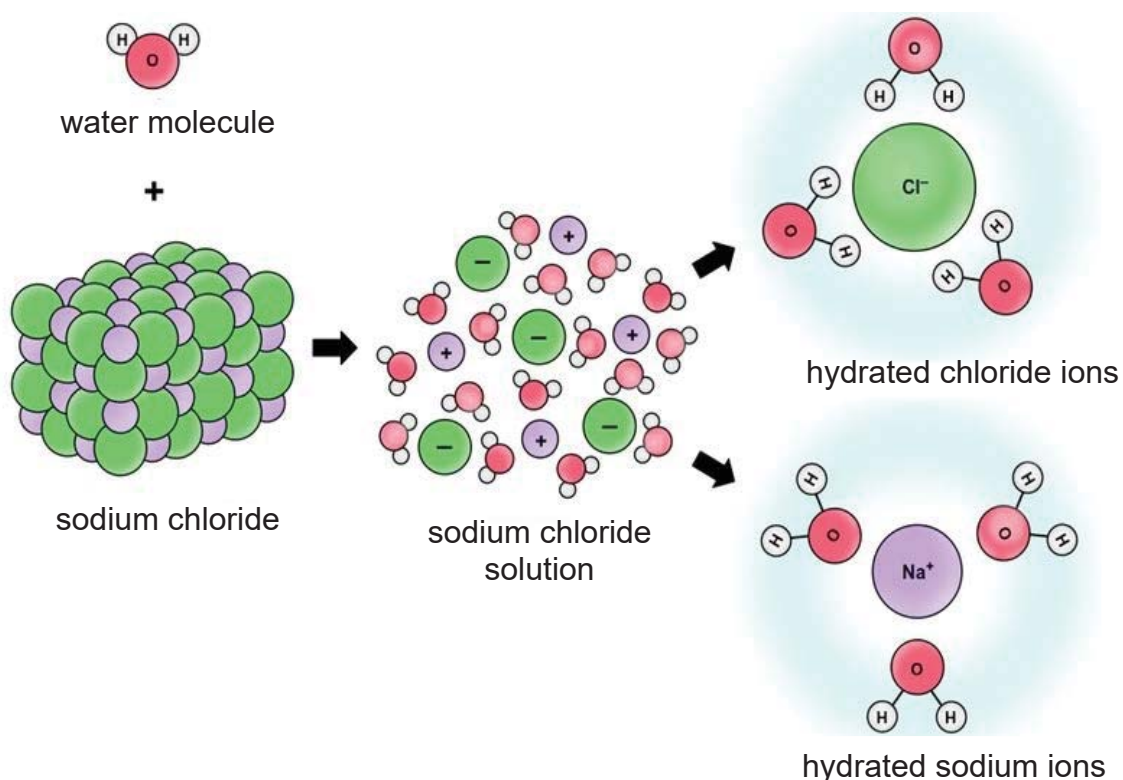


Figure B1.1

The solubility of sparingly soluble ionic compounds can be estimated from its solubility product, K_{sp} , which is only affected by temperature. The higher the K_{sp} value, the more soluble the compound will be.

Table B1.1 below shows the K_{sp} values of some common ionic compounds.

compound	chemical formula	K_{sp} (mol^2/dm^6) at 25°C
barium sulfate	BaSO_4	1×10^{-10}
calcium carbonate	CaCO_3	5×10^{-9}
calcium sulfate	CaSO_4	2×10^{-5}
silver chloride	AgCl	2×10^{-10}

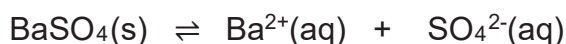
Table B1.1

Precipitation

By comparing the K_{sp} value and **ionic product** of a compound, we can predict whether precipitation of a certain compound will occur when two solutions are mixed together.

The **ionic product** is the product of the concentration of cation and anion present in the mixed solution.

For instance, when a sparingly soluble salt like barium sulfate dissolves in water, it dissociates into Ba^{2+} and SO_4^{2-} according to the equation below.



Ionic product = (concentration of Ba^{2+} ions in solution) x (concentration of SO_4^{2-} ions in solution)

Table B1.2 below shows whether precipitation will occur when comparing ionic product and K_{sp} of a compound.

types of solution	outcome
ionic product = K_{sp}	No precipitation.
ionic product < K_{sp}	No precipitation.
ionic product > K_{sp}	Precipitation is observed.

Table B1.2

- (a) Sodium sulfate is another soluble ionic compound.

Draw a similar diagram as the hydrated sodium ion or hydrated chloride ion to show a hydrated sulfate ion.

[2]

- (b) By comparing the two factors affecting solubility as described in the question, explain why sodium chloride is very soluble in water while silver chloride is only sparingly soluble.

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

- (c) Predict the relationship between temperature and K_{sp} value of an ionic compound.

..... [1]

- (d) State the least soluble compound found in **Table B1.1**.

..... [1]

- (e) Suggest the name of another ionic compound not present in **Table B1.1** that has a very low K_{sp} value.

..... [1]

- (f) Equal volume of a 0.01 mol/dm^3 calcium nitrate solution was added to a 0.0025 mol/dm^3 sodium sulfate solution to precipitate out calcium sulfate salt as shown in **Figure B1.2** below.

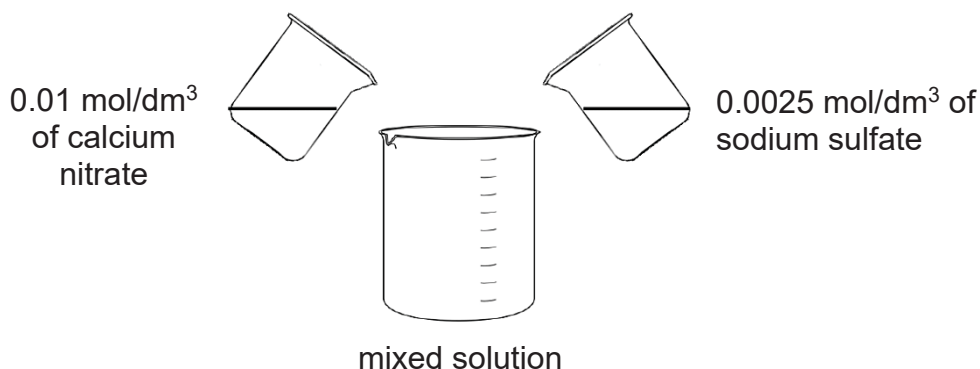


Figure B1.2

Determine, by calculation of ionic product in the **mixed** solution, and with reference to **Table B1.1** and **Figure B1.2**, if precipitation of any compound will occur.

Show your workings clearly in the space provided below.

[3]

- (g) Without further addition of any reagent, suggest two ways to increase the amount of solid precipitated out from a saturated solution.

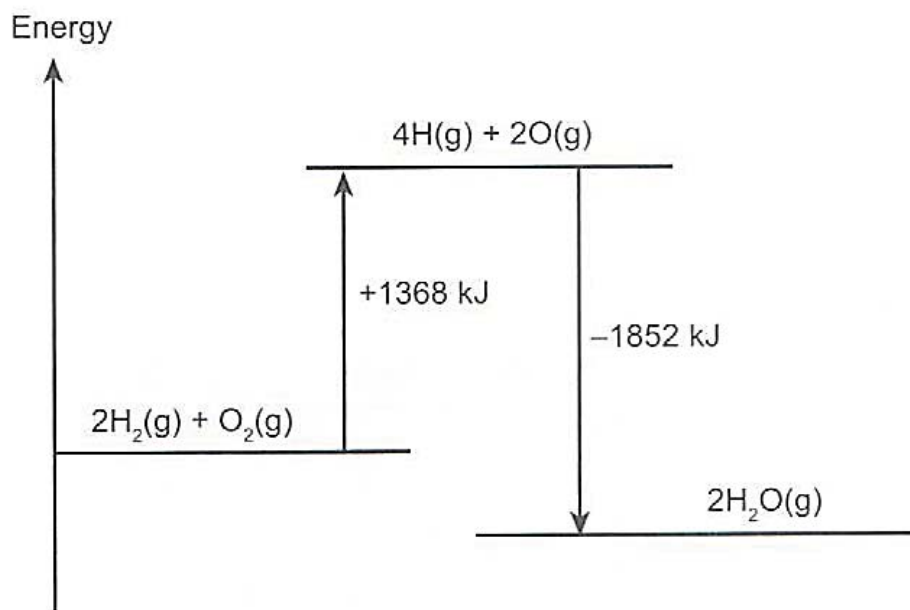
.....

.....

..... [2]

[12 marks]

B2 Hydrogen burns in oxygen to form water. The energy level diagram for the reaction is given below.



(a) Water can also be broken down into hydrogen and oxygen using electrolysis.

Electricity is used to provide energy for the electrolysis.

Complete the energy profile diagram for the electrolysis of water.

Your diagram should include

- the reactants and products
- the activation energy and its value
- the enthalpy change of the reaction and its value



[4]

(b) Complete the table.

fuel	enthalpy change when 1 mol of H ₂ is completely burned in kJ/mol	enthalpy change when 1 kg of H ₂ is completely burned in kJ/kg
hydrogen, H ₂		

[2]

(c) Some people think that hydrogen is a completely clean fuel.

Do you agree with the statement? Explain your answers.

.....

.....

..... [2]

[8 marks]

EITHER

B3 Caesium is used in atomic clocks, which help to define the length of a standard second.

(a) Write a chemical equation, with state symbols, to show what would happen if caesium atomic clocks were not stored in moisture-free environments.

..... [2]

(b) Both caesium and sodium are in Group I of the Periodic Table.

Compare the electronic structure of these two atoms and suggest a reason why caesium is more reactive than sodium.

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

(c) A student wants to investigate the relative reactivity of sodium, iron and zinc.

He planned to add sodium to aqueous iron carbonate and aqueous zinc carbonate.

Suggest reasons why his investigation will not work.

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

(d) Given the carbonates of the three metals, sodium carbonate, iron carbonate and zinc carbonate, outline an experiment to determine which is the most reactive metal. Include in your answers, any assumptions and measurements you would make, and how you intend to process the data collected to draw your conclusions.

.....
.....
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.....
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.....
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.....
..... [5]

[10 marks]

OR

B3 Figure B3.1 shows the composition of the atmosphere on Venus, Earth and Mars.

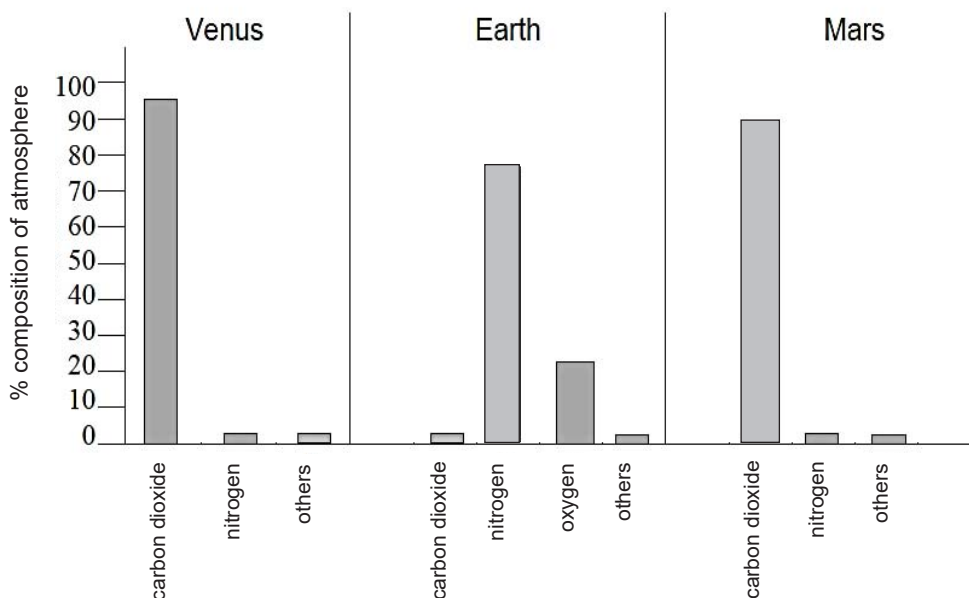


Figure B3.1

- (a) Earth lies between Venus and Mars. The composition of gases in the three atmospheres is expected to follow a trend. However, it was found that Earth's atmosphere deviates from the trend.

Predict the composition of Earth's atmosphere based on this trend.

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

- (b) How does the atmosphere on Venus differ from the atmosphere on Earth?

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

- (c) Venus is often called Earth's twin since it has almost the same size and density as Earth. Initially, Earth's atmosphere was similar to that of Venus.

Suggest and explain what caused the composition of Earth's atmosphere to change. Include the processes involved and giving chemical equations for any reactions.

.....

.....

.....

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.....

.....

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..... [5]

[10 marks]

End of Paper

The Periodic Table of Elements

		Group																																																																													
I	II	III	IV	V	VI	VII	0																																																																								
3 Li lithium 7	4 Be beryllium 9	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	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 -	113 Nh nihonium -	114 Fl flerovium -	115 Lv livermorium -	116 Og oganeson -

1
H
hydrogen
1

Key
proton (atomic) number
atomic symbol
name
relative atomic mass

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
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 -

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

