NEW TOWN SECONDARY SCHOOL
End-Of-Year Examination
Secondary 3 Express

NAME

CLASS

INDEX NUMBER

Chemistry

Paper 1 Multiple Choice

6092/01
11 October 2022
1 hour
1010 – 1110

Additional Materials: OTAS

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class in the spaces provided above.
Write in dark blue or black pen.
Do not use staples, highlighters, glue or correction fluid/tape.

There are 40 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 OTAS.

Read the instructions on the OTAS very carefully.

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.
The total marks for this paper is 40.
A copy of the Periodic Table is printed on page 13.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **13** printed pages and **1** blank page.

Setter: Ms Koh Wendy

1 An experiment was conducted to determine the time needed for 5g of copper(II) carbonate to completely decompose on heating.

The following apparatus were found in the laboratory:

1 Bunsen burner
2 boiling tube
3 stopwatch
4 thermometer
5 weighing balance

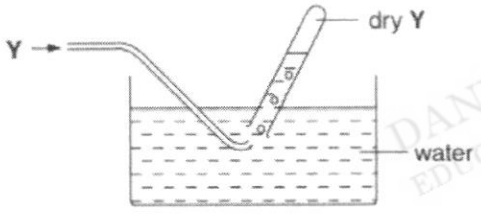
Which apparatus can be used to conduct the experiment?

A 1, 2 and 3
B 1, 3 and 5
C 1, 2, 3 and 5
D 1, 3, 4 and 5

2 Gas Y is less dense than air and dissolves in water to give a solution of pH 2.

Which method is used to collect a dry sample of the gas?

A



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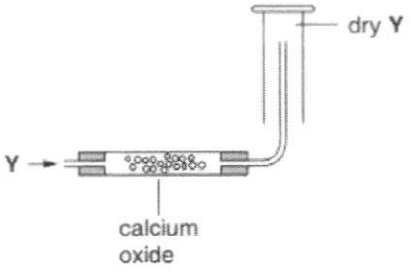

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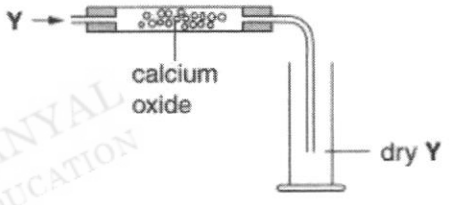

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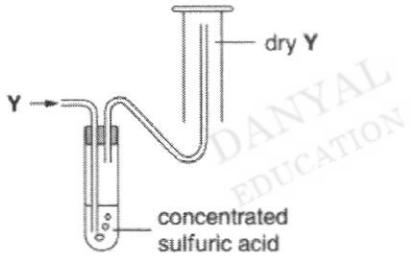


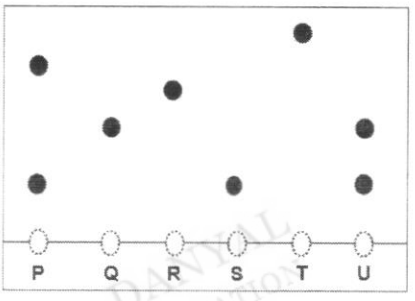
3 A coloured substance is made in an experiment. The list shows some methods to determine if the substance is pure.

1 test the substance using paper chromatography
2 test the substance with litmus paper
3 dissolve the substance in water
4 measure the melting point of the substance

Which method can be used to determine if this substance is pure?

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

4 The diagram below shows a chromatogram of an analysis of the dyes present in six different ink samples, **P**, **Q**, **R**, **S**, **T** and **U**.

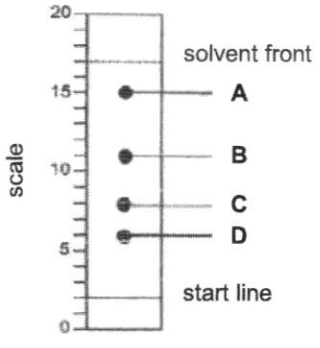


How many different dyes were used to make these six ink samples?

A 4
B 5
C 6
D 8

5 The diagram shows a chromatogram obtained from the analysis of a drug sample.

If the drug has an R_f value of 0.88, at which point on the chromatogram is the spot found?

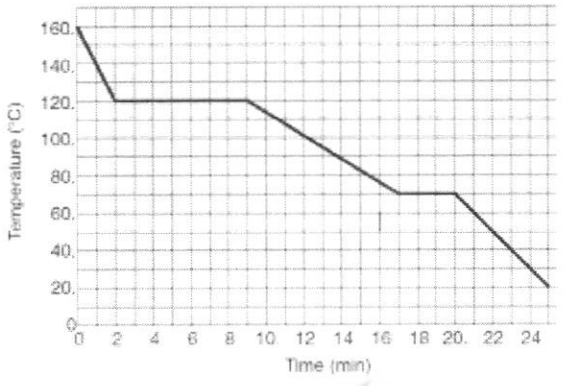


6 The table shows the melting and boiling points of four substances.

Which substance is a liquid at 100 °C?

	melting point / °C	boiling point / °C
A	–189	50
B	–28	99
C	–10	129
D	142	278

7 The graph shows the change in temperature with time when a gaseous substance X is being cooled.



Which statement about substance X is correct?

A X exists in the gaseous state between 2 to 9 minutes.
B X exists as a mixture of gas and liquid at 12 minutes.
C X has a boiling point of 70 °C.
D X is a solid at room temperature.

8 An ion, L^{2+}, has m electrons and a nucleon number of n.

Which row shows the correct number of sub-atomic particles for an atom of L?

	number of protons	number of neutrons
A	m	$n - m$
B	$m - 2$	$n + (m - 2)$
C	$m + 2$	$n + (m + 2)$
D	$m + 2$	$n - (m + 2)$

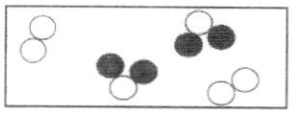
9 Which statement about an element is always true?

A An element can be broken down into simpler substances by strong heating.
B An element comprises of molecules in fixed proportions.
C An element comprises of one type of atoms.
D An element exists as molecules.

10 The symbols ● and ○ represent atoms of different elements.

Which diagram shows a mixture of compounds?

A



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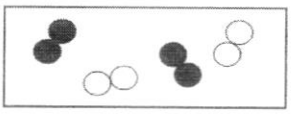

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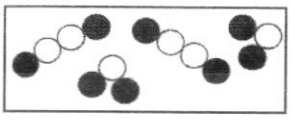

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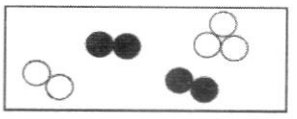
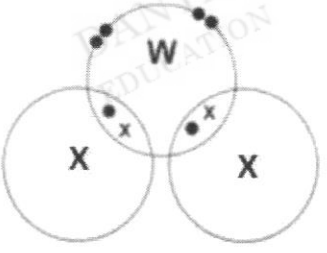


11 Which statement is correct for all ionic compounds?

A They are formed when metals share electrons with non-metals.
B They conduct electricity in all states.
C They have high melting and boiling points.
D They have low density.

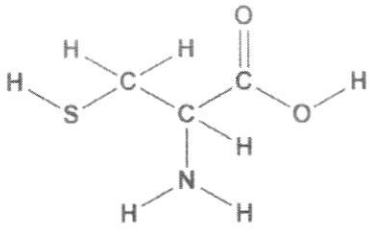
12 The diagram below shows the 'dot-and-cross' diagram of a molecule formed when element W reacted with element X.



Given that W is found in Period 2 of the Periodic Table, which statement about W is correct?

A W conducts electricity in the liquid state.
B W exists as monatomic molecules.
C W has low melting point and boiling point.
D W reacts with magnesium to form a covalent compound.

13 The diagram shows the full structural formula of an amino acid that is often used to manufacture medicines.



How many valence electrons are **not** involved in bonding?

A 8
B 14
C 26
D 28

14 Which statement explains why iron conducts electricity?

A Iron has free moving atoms.
B Iron has free moving electrons.
C Iron has free moving cations.
D Iron has free moving cations and electrons.

15 Antacid tablets dissolve in water to give an alkaline solution.
A few drops of Universal Indicator is added to the solution.

Which row shows the pH of the solution and the colour of the solution after Universal indicator is added?

	pH	colour of solution
A	greater than 7	blue
B	greater than 7	orange
C	less than 7	blue
D	less than 7	orange

16 Solution X and Y are two commonly used acids.

X: 1 dm^3 of 1.0 mol/dm^3 hydrochloric acid, HCl.
Y: 1 dm^3 of 1.0 mol/dm^3 ethanoic acid, CH_3COOH.

Which statement about solutions X and Y is correct?

A X is more concentrated than Y.
B X has a higher pH than Y.
C X and Y are both strong acids.
D X and Y both contain 1 mol of H^+ ions.

17 The table shows some information about three indicators.

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

If equal volumes of these three indicators are added to the same beaker containing a liquid of pH 6, what is the colour observed?

A blue
B yellow
C green
D orange

18 An aqueous reagent is added to a solution of ammonium nitrate.
When the mixture is heated, ammonia gas is produced.

What is the aqueous reagent added?

A potassium hydroxide
B lead(II) hydroxide
C nitric acid
D sodium nitrate

19 When a piece of lithium was added to a beaker of water, effervescence was observed. The gas was collected and tested.

Which test and observation could be used to confirm the identity of the gas produced?

A A burning splint extinguishes with a 'pop' sound.
B A glowing splint relights.
C Damp red litmus paper turns blue and then white.
D Gas forms white precipitate in limewater.

20 Which solution forms a white precipitate with both dilute sulfuric acid and aqueous silver nitrate?

A barium chloride
B barium nitrate
C lead(II) iodide
D lead(II) nitrate

21 A salt P was dissolved in water to form a colourless solution. On addition of aqueous sodium hydroxide to the colourless solution, a white precipitate was formed which dissolved in excess aqueous sodium hydroxide. Aluminium powder was then added and the resulting mixture was warmed. A gas was produced, which turned damp red litmus paper blue.

What is P?

A aluminium sulfate
B calcium nitrate
C sodium sulfate
D zinc nitrate

22 The chemical equations for two reactions are shown.

1 $2\underline{Hg}O \rightarrow 2Hg + O_2$

2 $2Na\underline{N}O_2 + O_2 \rightarrow 2NaNO_3$

In which of these reactions is the underlined substance reduced?

	1	2
A	✓	✓
B	✓	×
C	×	✓
D	×	×

✓ : reduced
× : not reduced

23 Hydrogen peroxide was added separately to aqueous potassium iodide and acidified potassium manganate(VII).

Which row describes the correct colour changes?

	aqueous potassium iodide	acidified potassium manganate(VII)
A	colourless to brown	purple to colourless
B	colourless to brown	remains purple
C	brown to colourless	purple to colourless
D	brown to colourless	remains purple

24 Which pair of reagents **cannot** be used to safely prepare a pure sample of sodium sulfate?

A sodium and sulfuric acid
B sodium carbonate and sulfuric acid
C sodium oxide and sulfuric acid
D sodium hydroxide and sulfuric acid

25 Which salt could be prepared by the precipitation method?

A ammonium chloride
B calcium sulfate
C potassium chloride
D silver nitrate

26 Phosphoric acid, H_3PO_4, reacts with lithium carbonate as shown in the chemical equation below.

$$2H_3PO_4\,(aq) + 3Li_2CO_3\,(aq) \rightarrow 2Li_3PO_4\,(aq) + 3H_2O\,(l) + 3CO_2\,(g)$$

What is the ionic equation for this reaction?

A $PO_4^{3-}\,(aq) + 3Li^+\,(aq) \rightarrow Li_3PO_4\,(aq)$
B $2H^+\,(aq) + CO_3^{2-}\,(aq) \rightarrow H_2O\,(l) + CO_2\,(g)$
C $2H^+\,(aq) + Li_2CO_3\,(aq) \rightarrow 2Li^+\,(aq) + H_2O\,(l) + CO_2\,(g)$
D $H_3PO_4\,(aq) \rightarrow 3H^+\,(aq) + PO_4^{3-}\,(aq)$

27 Element Q has 7 protons.
Element R has 8 more protons than Q.

Which statement about element R is **not** correct?

A R is in the same group as Q in the Periodic Table.
B R is in a different period as Q in the Periodic Table.
C R has more electron shells than Q.
D R has more electrons in its outer shell than Q.

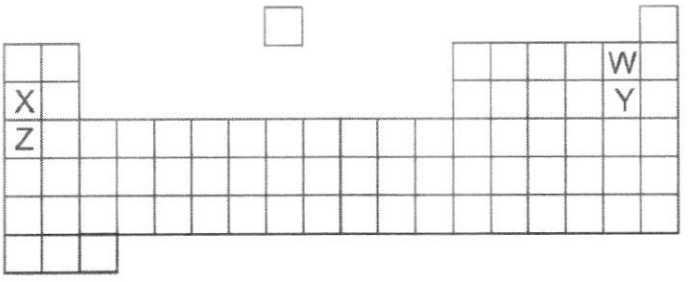
28 Which statement shows the general trend of the elements across Period 3 from sodium to chlorine?

A The boiling points of the elements increase.
B The electrical conductivity of the elements increase.
C The metallic character decreases.
D The bond strength decreases from ionic to covalent.

29 Which property is typical of transition metals?

A They have low densities.
B They have low melting points.
C They form ions with a 2+ charge.
D They form coloured compounds.

30 The diagram shows elements W, X, Y and Z in the Periodic Table.
The letters are not the chemical symbols of the elements.



Which statement about the reactivity of the elements is correct?

A X is more reactive than Z, W is more reactive than Y.
B X is more reactive than Z, Y is more reactive than W.
C Z is more reactive than X, W is more reactive than Y.
D Z is more reactive than X, Y is more reactive than W.

31 Which substance contains the same number of atoms as 10.8 dm^3 of oxygen gas at room temperature and pressure?

A 0.45 mol of neon gas
B 0.9 mol of chlorine gas
C 12.6 g of nitrogen gas
D 1.8 g of hydrogen gas

32 A chloride, $EC\mathit{l}_n$, contains 12.0 g of chlorine and 0.338 mol of element E.

Which group in the Periodic Table does element E belong to?

A I **B** II **C** III **D** V

33 The equation for the burning of methane in oxygen is shown below.

$$CH_4\,(g) + 2O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(\mathit{l})$$

Which statement describes the reaction?

A 1 g of methane reacts with 2 g of oxygen.
B 1 mol of water is produced when 2 mol of oxygen is reacted.
C 16 cm^3 of methane is required to produce 32 cm^3 of water.
D 36 g of water is produced when 16 g of methane is reacted.

34 N_2O_4 is a toxic gas that can be removed by reacting it with sodium hydroxide as shown in the equation.

$$N_2O_4\,(g) + 2NaOH\,(aq) \rightarrow NaNO_3\,(aq) + NaNO_2\,(aq) + H_2O\,(l)$$

What is the exact volume of 0.5 mol/dm^3 sodium hydroxide required to remove 0.04 mol of N_2O_4?

A 16 cm^3
B 40 cm^3
C 80 cm^3
D 160 cm^3

35 30 cm^3 of sulfur dioxide was reacted with 20 cm^3 of oxygen as shown in the equation below.

$$2SO_2\,(g) + O_2\,(g) \rightarrow 2SO_3\,(g)$$

What is the final volume of gases obtained at room temperature and pressure?

A 20 cm^3
B 25 cm^3
C 30 cm^3
D 35 cm^3

36 When 21.0 g of sodium hydrogencarbonate, $NaHCO_3$, was strongly heated, 1.50 dm^3 of carbon dioxide gas, measured at room temperature and pressure, was produced.

$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$$

What is the percentage yield of carbon dioxide?

A 25 %
B 50 %
C 75 %
D 100 %

37 A student wants to make 0.25 mol/dm^3 nitric acid.

What is the volume of water that has to be **added** to 40.0 cm^3 of 2.00 mol/dm^3 nitric acid to obtain the required concentration?

A 24 cm^3
B 80 cm^3
C 280 cm^3
D 320 cm^3

38 Which process is the enthalpy change always positive?

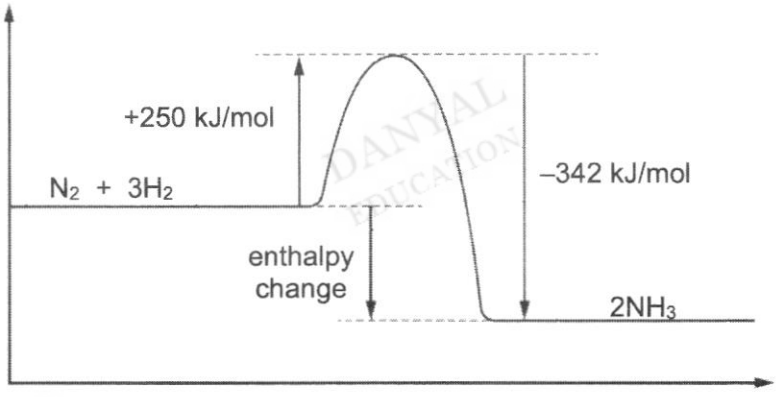
A combustion
B evaporation
C neutralisation
D respiration

39 The reaction between magnesium and hydrochloric acid is an example of an exothermic reaction.

Which statement describes this reaction?

A Heat is absorbed from the surroundings.
B The thermometer shows a decrease in temperature.
C The bonds in the reactants are weaker than the bonds in the products.
D The total energy required to break bonds is lower than the total energy released on bond forming.

40 The energy profile diagram for the formation of ammonia from the reaction of nitrogen and hydrogen is as shown.



What is the enthalpy change for this reaction?

A –92 kJ/mol
B +92 kJ/mol
C –592 kJ/mol
D +592 kJ/mol

NEW TOWN SECONDARY SCHOOL
End-Of-Year Examination
Secondary 3 Express

NAME

CLASS

INDEX NUMBER

Chemistry
Paper 2

6092/02
7 October 2022
1 hour 45 minutes
0800 - 0945

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class in the spaces provided above.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, highlighters, glue or correction fluid/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.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is provided on page 18.

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

For Examiner's Use		
Section A	A1	
	A2	
	A3	
	A4	
	A5	
	A6	
Section B	B7	
	B8	
	B9 E / O	
	Total	

Setter: Ms Koh Wendy

This paper consists of **18** printed pages.

Section A (50 marks)

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

A1 Complete Table 1.1 to show the electronic configuration of three particles **X**, **Y** and **Z**.

Table 1.1

particle	number of protons	number of electrons	electronic configuration
X		5	
Y^+	3		
Z^-		10	

[Total: 3]

A2 Table 2.1 shows some information about three liquids, ethanol, methanol and hexane.

Table 2.1

liquid	molecular formula	boiling point (°C)	density (g/cm^3)
ethanol	C_2H_6O	78	0.79
methanol	CH_4O	65	0.79
hexane	C_6H_{14}	69	0.66

(a) Name an apparatus that can be used to measure accurately 25.0 cm^3 of each liquid. [1]

.....

(b) A liquid mixture of methanol and hexane is separated using the apparatus shown in Fig. 2.2.

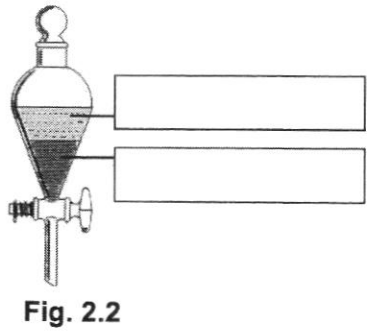


Fig. 2.2

(i) Name the apparatus in Fig. 2.2. [1]

.....

(ii) Write the names of the liquids in the correct boxes. [1]

(iii) Explain your answer in **(b)(ii)**. [1]

.....

(c) Another liquid mixture of ethanol and hexane is separated by fractional distillation as shown in Fig. 2.3.

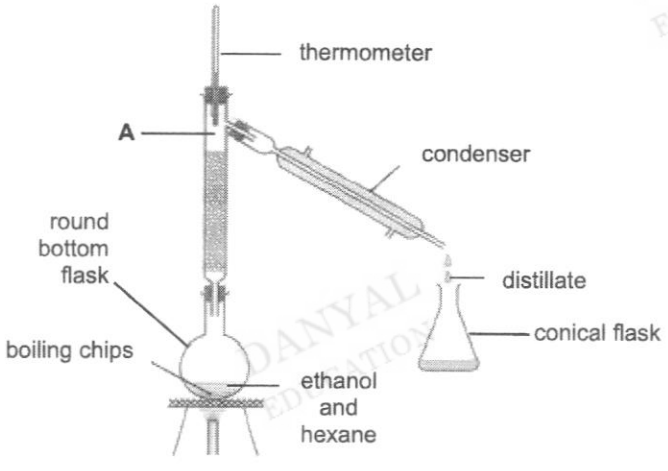


Fig. 2.3

(i) Name the liquid that remains in the round bottom flask at the end of the process. [1]

.....

(ii) State the purpose of the boiling chips. [1]

.....

(iii) On Fig. 2.4, sketch a graph of how the temperature changes from room temperature until **both** liquids have distilled over into the conical flask.

Label the boiling points of both liquids in your graph. [2]

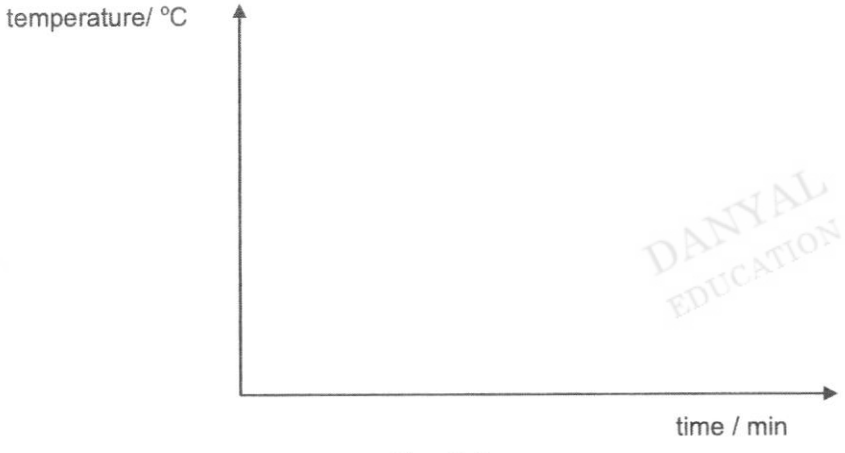


Fig. 2.4

(iv) Describe the arrangement and movement of the particles at the part labelled **A** in Fig. 2.3. [2]

.....

.....

.....

[Total: 10]

A3 Fig. 3.1 shows a set-up used to investigate the rate of diffusion of two gases, methylamine, CH_3NH_2, and hydrogen chloride, HCl. Methylamine has similar chemical properties to ammonia.

When the two gases meet in the tube, a reaction takes place and a white solid, methylammonium chloride, CH_3NH_3Cl, is produced.

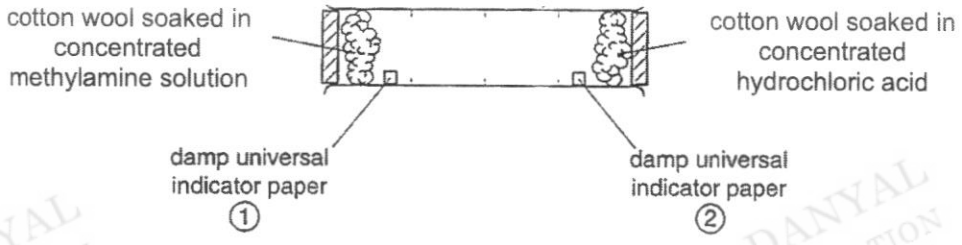


Fig. 3.1

(a) Write a balanced chemical equation, with state symbols, for the reaction that occurred in the tube. [1]

.....

(b) State the colour of the Universal indicator papers at the end of the reaction. [2]

colour of Universal indicator paper 1 .....

colour of Universal indicator paper 2 .....

(c) **(i)** Indicate on Fig 3.1 with an '**X**' where the white solid would be formed inside the tube. [1]

(ii) Explain your answer in **(c)(i)**. [3]

.....

.....

.....

.....

.....

[Total: 7]

A4 **(a)** Nitrogen is the most abundant gas in the air. It is an inert gas and can be used to store reactive metals such as sodium. There are two stable isotopes of nitrogen, ^{14}N and ^{15}N.

(i) Define the term *isotopes*. [1]

.....

(ii) Draw a 'dot-and-cross' diagram to show the bonding in a molecule of nitrogen. [2]

(iii) Use your diagram in **(a)(ii)** to explain why nitrogen is an inert gas. [1]

.....

.....

(b) Nitrogen is an important element required for good plant growth. Hence it is a major component for many fertilisers, usually in the form of ammonium nitrate, NH_4NO_3, and urea, $CO(NH_2)_2$.

(i) A manufacturer claims that fertiliser containing urea is a better choice as it contains more nitrogen than the same mass of ammonium nitrate.

Calculate the percentage by mass of nitrogen in each compound and state whether the claim is true. [2]

(ii) Urea is manufactured by the reaction as shown.

$$2NH_3 + CO_2 \rightarrow CO(NH_2)_2 + H_2O$$

Calculate the mass of urea produced when 50 g of ammonia is reacted with 30 dm^3 of carbon dioxide. [3]

(c) Table 4.1 shows two oxides of nitrogen.

Table 4.1

oxide	chemical formula	type of oxide			
		neutral	acidic	basic	amphoteric
nitrogen monoxide					
nitrogen dioxide					

(i) Write the chemical formula of the two oxides of nitrogen in Table 4.1. [1]

(ii) Identify the type of oxide by ticking (✓) the appropriate boxes in in Table 4.1 [2]

[Total: 12]

A5 Chlorine and bromine are halogens found in Group VII of the Periodic Table. They show a trend in their physical and chemical properties.

(a) Complete Table 5.1 to show the properties of chlorine and bromine. [2]

Table 5.1

halogen	physical state at room temperature and pressure	colour
chlorine		
bromine		

(b) When chlorine is added to an aqueous solution of potassium bromide, a reaction occurs.

(i) State the observations for this reaction. [1]

.....

(ii) Explain the reaction that has occurred. [2]

.....

.....

(iii) Write a balanced **ionic** equation, with state symbols, for the reaction. [2]

.....

(c) Chlorine reacts with bromine to form bromine chloride as shown by the chemical equation.

$$Cl_2 + Br_2 \rightarrow 2BrCl$$

The table shows the bond energies.

	Cl–Cl	Br–Br	Br–Cl
bond energy in kJ/mol	244	193	204

(i) Use the data in the table to calculate the

- energy for bond breaking [1]

- energy for bond making [1]

(ii) Hence calculate the enthalpy change of the reaction. [1]

[Total: 10]

A6 **K** is a mixture of compounds **L** and **M**.

Fig. 6.1 is a flowchart that shows a series of chemical reactions carried out on mixture **K**.

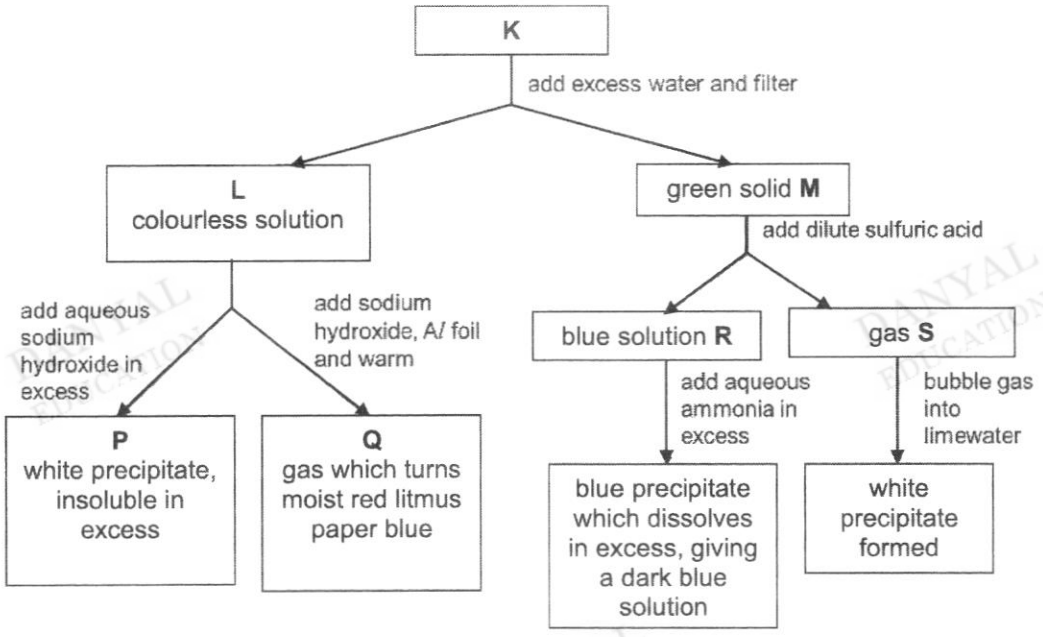


Fig 6.1

(a) Identify **L**, **M**, **P**, **Q**, **R** and **S**. [6]

L .....

M .....

P .....

Q .....

R .....

S .....

(b) Write a balanced chemical equation for any **one** of the reactions above. [2]

.....

[Total: 8]

Section B (30 marks)

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

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

B7 Acids have many uses in industries. One example is sulfuric acid which is commonly used as industrial cleaners and for the manufacture of other chemicals. Sulfuric acid is a strong acid that is produced on a large scale, with an annual world production of 230 million tonnes. One method to manufacture sulfuric acid is known as the *Wet Sulfuric Acid Process*, as shown in the following steps:

step 1 Hydrogen sulfide, H_2S, is burned in oxygen to produce sulfur dioxide and water.

step 2 The sulfur dioxide produced then reacts with more oxygen to form sulfur trioxide.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 \qquad \Delta H = -198 \text{ kJ / mol}$$

step 3 Sulfur trioxide is then dissolved in water to produce sulfuric acid.

$$SO_3 + H_2O \rightarrow H_2SO_4 \qquad \Delta H = -191 \text{ kJ / mol}$$

Besides industrial uses, acids are also commonly found in food and beverages. Orange juice contains citric acid which contributes a sour taste. The amount of citric acid present in orange juice determines the sourness of the juice. The concentration of citric acid, H_3A, can be determined by titration with an alkali. The chemical equation for the reaction between citric acid and sodium hydroxide is as shown.

$$H_3A\,(aq) + 3NaOH\,(aq) \rightarrow Na_3A\,(aq) + 3H_2O\,(l)$$

(a) (i) Write a balanced chemical equation for the reaction in **step 1**. [2]

.....

(ii) Draw a 'dot and cross' diagram to show the bonding in H_2S. Show only the valence electrons. [2]

(b) **(i)** Explain, in terms of oxidation states, whether **step 2** is a redox reaction. [2]

.....

.....

.....

(ii) On Fig 7.1, draw an energy profile diagram of the reaction in step 2. Your diagram should show and label

- the reactants and products,
- the activation energy and enthalpy change of reaction. [3]

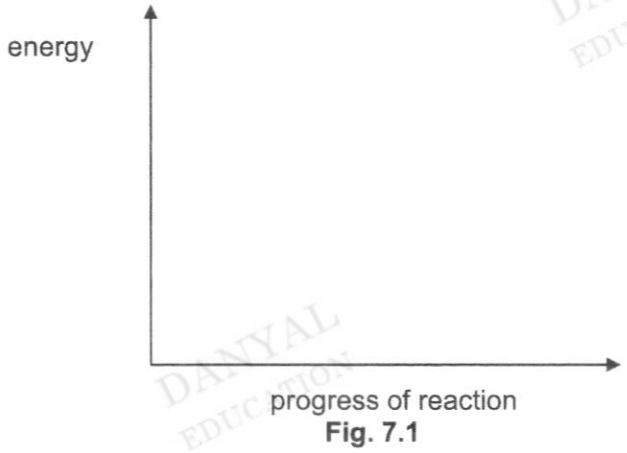


Fig. 7.1

(c) A sample of bottled orange juice was tested in a laboratory to determine the concentration of citric acid present. 10 cm^3 sample of orange juice was diluted to 100 cm^3 with distilled water. 25.0 cm^3 of the diluted solution required 30.50 cm^3 of 0.0100 mol/dm^3 sodium hydroxide for complete reaction.

(i) Calculate the number of moles of citric acid present in the 10 cm^3 sample of orange juice. [2]

(ii) Hence calculate the concentration of citric acid present in the orange juice. [1]

[Total: 12]

B8 **(a)** Suggest the reagents and steps required to prepare a pure sample of magnesium chloride. [4]

.....

.....

.....

.....

.....

.....

.....

.....

(b) **(i)** Write a balanced chemical equation for the reaction you have chosen in **(a)**. [2]

.....

(ii) Draw a 'dot-and-cross' diagram of magnesium chloride.
Show only the valence electrons. [2]

[Total: 8]

EITHER

B9 **(a)** Carbon nanotubes were first discovered in 1952 by two Russian scientists. It is an allotrope of carbon with a diameter that is about one-thousandth of the thickness of a human hair.

The structure of the different carbon allotropes are shown in Fig 9.1.

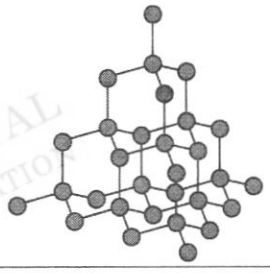
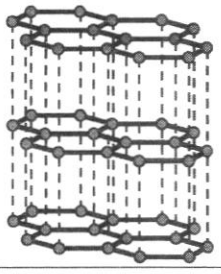
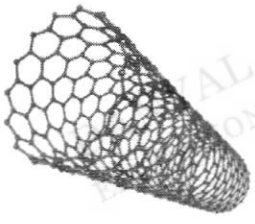
allotropes of carbon		
		
diamond	graphite	carbon nanotube

Fig. 9.1

(i) Explain, in terms of structure and bonding, why carbon nanotubes can withstand high temperatures up to 750 °C. [2]

.....

.....

.....

.....

.....

(ii) Carbon nanotubes are also good electrical conductors. Explain this property in terms of its bonding. [2]

.....

.....

.....

.....

.....

(b) Many materials that we use in daily life contain carbon. Plastic bags are very large molecules made from smaller hydrocarbon molecules.

Hydrocarbon molecules contain only carbon and hydrogen atoms.
One such hydrocarbon, **X**, contains 85.7% by mass of carbon atoms.

The relative molecular mass of **X** is 28.

(i) Calculate the empirical formula of **X**. [3]

(ii) Hence determine the molecular formula of **X**. [1]

(iii) Based on your answer in **(b)(ii)**, explain why **X** exists as a gas at room temperature and pressure. [2]

.....

.....

.....

[Total: 10]

OR

B9 **(a)** An element **Y** burns in oxygen to form a compound, Y_2O_3, which has a relative molecular mass of 160.

(i) Determine the identity of element **Y**. [2]

(ii) Explain, in terms of structure and bonding, if element **Y** can conduct electricity. [2]

.....

.....

.....

.....

(iii) State if the compound Y_2O_3 has a low or high melting point. Explain your answer. [2]

.....

.....

.....

.....

(b) Many organic molecules contain oxygen. One example is compound **Z** which has the following composition by mass:

C, 40.0%; H, 6.7%; O, 53.3%.

The relative molecular mass of **Z** is 180.

(i) Calculate the empirical formula of **Z**. [3]

(ii) Hence determine the molecular formula of **Z**. [1]

[Total: 10]

-------- End of paper --------

NEW TOWN SECONDARY SCHOOL
End of Year Examination
Secondary 3 Express

NAME

CLASS | | | | INDEX NUMBER | | |

Chemistry
Paper 1 Multiple Choice

Additional Materials: OTAS

6092/01
11 October 2022
1 hour
1010 – 1110

ANSWERS

Setter: Ms Koh Wendy

Paper 1

Q1	Q2	Q3	Q4	Q5
C	D	B	B	A
Q6	Q7	Q8	Q9	Q10
C	D	D	C	B
Q11	Q12	Q13	Q14	Q15
C	C	B	B	A
Q16	Q17	Q18	Q19	Q20
D	B	A	A	A
Q21	Q22	Q23	Q24	Q25
D	B	A	A	B
Q26	Q27	Q28	Q29	Q30
B	D	C	D	C
Q31	Q32	Q33	Q34	Q35
C	A	D	D	D
Q36	Q37	Q38	Q39	Q40
B	C	B	D	A

NEW TOWN SECONDARY SCHOOL
End of Year Examination
Secondary 3 Express

NAME

CLASS

INDEX NUMBER

Chemistry
Paper 2

6092/02
7 October 2022
1 hour 45 minutes
0800 - 0945

Mark Scheme

Setter: Ms Koh Wendy

Section A

A1 Complete Table 1.1 to show the electronic configuration of three particles, **X**, **Y** and **Z**.

Table 1.1

particle	number of protons	number of electrons	electronic configuration
X	5	5	2, 3
Y^+	3	2	2
Z^-	9	10	2, 8

[Total: 3]

Many students did not take into account that Y and Z are both ions and gave "3" for number of electrons for Y^+, and "10" for number of protons for Z^-.

A2 Table 2.1 shows some information about three liquids, ethanol, methanol and hexane.

Table 2.1

liquid	molecular formula	boiling point (°C)	density (g/cm^3)
ethanol	C_2H_6O	78	0.79
methanol	CH_4O	65	0.79
hexane	C_6H_{14}	69	0.66

(a) Name an apparatus that can be used to measure accurately 25.0 cm^3 of each liquid. [1]

Pipette (Accept: burette; because precision is better than pipette)

(b) A liquid mixture of methanol and hexane is separated using the apparatus shown in Fig. 2.2.

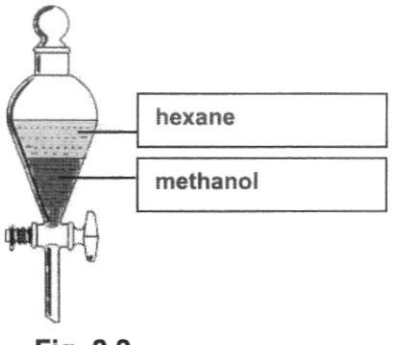


Fig. 2.2

(i) Name the apparatus in Fig. 2.2. [1]

Separating funnel

(ii) Write the names of the liquids in the correct boxes. [1]
Both correct [1]

(iii) Explain your answer in **(ii)**. [1]

Hexane with lower density will float on top of methanol with the higher density.

Accept vice versa

Many students only mentioned that one liquid has a higher (or lower) density and did not explain its effect (sink or float or WTTE).

(c) Another liquid mixture of ethanol and hexane is separated by fractional distillation as shown in Fig. 2.3.

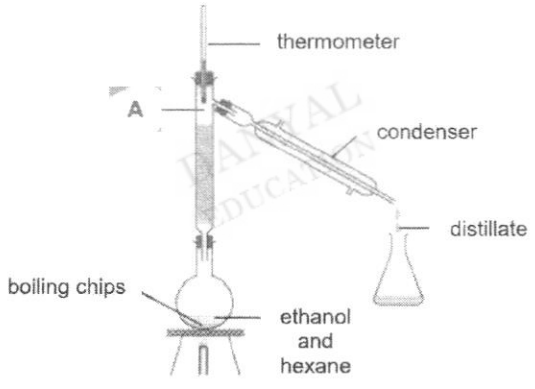


Fig. 2.3

(i) Name the liquid that remains in the flask at the end of the process.

Ethanol [1]

(ii) State the purpose of the boiling chips. [1]

For smooth boiling

A few students confused this with the purpose of a condenser.

(iii) On Fig. 2.4, sketch a graph of how the temperature changes from room temperature until both liquids have distilled over into the conical flask.
Label the boiling points of both liquids in your graph. [2]

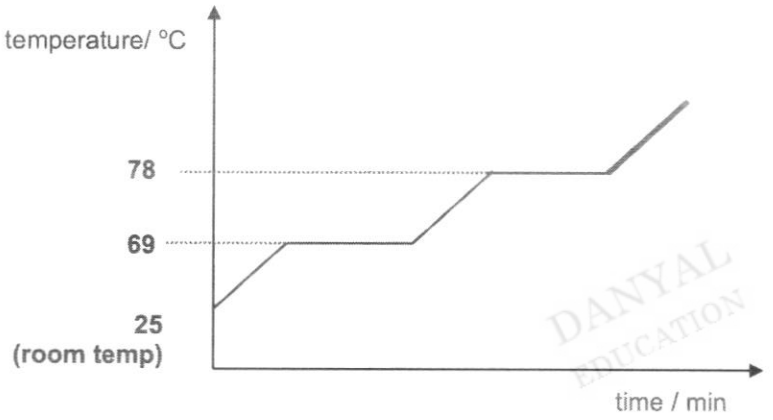


Fig. 2.4

[1] correct "shape" of heating curve
Many students did not draw the part of the graph shown in red (but not penalised)

[1] correct labelling of b.p. of both liquids
A handful of students started the graph at the "origin" without labelling that it is room temperature.

(v) Describe the arrangement and movement of the particles at the part labelled **A** in Fig. 2.3. [2]

Part labelled A – gas / vapour

[1] arrangement: far apart AND random/irregular/disorderly

[1] movement: random AND fast/rapid

[Total: 10]

A3 Fig. 3.1 shows a set-up used to investigate the rate of diffusion of two gases, methylamine, CH_3NH_2, and hydrogen chloride , HCl. Methylamine has similar properties to ammonia.

When the two gases meet in the tube, a reaction takes place and a white solid, methylammonium chloride, CH_3NH_3Cl, is produced.

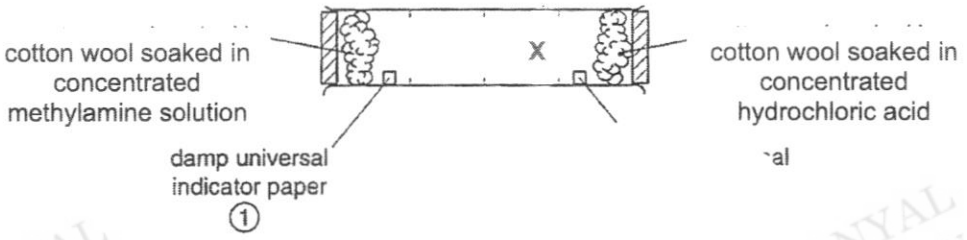


Fig. 3.1

(i) Write a balanced chemical equation, with state symbols, for the reaction that occurred in the tube. [1]

CH_3NH_2 (g) + HCl (g) → CH_3NH_3Cl (s)
[1] for correct state symbols, only if chemical formula are correct
Many students did not read the question carefully and gave (aq) for the state symbols of CH_3NH_2 and HCl.

(ii) State the colour of the Universal indicator papers at the end of the reaction. [2]

colour of Universal indicator paper 1 **blue**
Reject: violet, purple (methylamine is a weak base – similar properties to ammonia)

colour of Universal indicator paper 2 **orange / red**
Reject: yellow (hydrochloric acid is a strong acid)

(iii) Indicate on Fig 3.1 with an '**X**' where the white solid would be formed inside the tube. [1]
Accept anywhere on the right side, AFTER the middle

(iv) Explain your answer in **(iii)**. [3]

[1] correct Mr of CH_3NH_2 AND Mr of HCl

[1] Mr of CH_3NH_2 is smaller than Mr of HCl

[1] CH_3NH_2 will diffuse faster than HCl

Accept vice-versa explanation for 2nd and 3rd marking point
A number of students compared the Mr without giving the values.
[Total: 7]

A4 **(a)** Nitrogen is the most abundant gas in the air. It is an inert gas and can be used to store reactive metals such as sodium. There are two stable isotopes of nitrogen, ^{14}N and ^{15}N.

(i) Define the term *isotopes*. [1]

Atoms (of the same element) with same number of protons but different number of neutrons.

(ii) Draw a 'dot-and-cross' diagram to show the bonding in a molecule of nitrogen. [2]

[1] correct number of electrons for each N atom
Accept if only valence electrons shown

[1] 3 pairs of electrons shared

Many students drew 4 pairs of electrons shared between 2 N atoms.
For those who drew the correct bonding, many did not show the valence electrons not involved in bonding as a pair.

(iii) Use your diagram in **(ii)** to explain why nitrogen is an inert gas.

A lot of energy is required to overcome the strong triple bonds between the N atoms.

[1]

(b) Nitrogen is an important element required for good plant growth. Hence it is a major component for many fertilisers, usually in the form of ammonium nitrate, NH_4NO_3, and urea, $CO(NH_2)_2$.

(i) A manufacturer claims that fertiliser containing urea is a better choice as it contains more nitrogen than ammonium nitrate.
Calculate the percentage by mass of nitrogen in each compound and state whether the claim is true.
Show, by calculations, whether this claim is true. [2]

Mr of $CO(NH_2)_2$ = 12 + 16 + 2(14 + 2) = 60
Mr of NH_4NO_3 = 14 + 4(1) + 14 + 3(16) = 80

[1] Percentage by mass of N in $CO(NH_2)_2$ = [2(14) / 60] x 100 = 46.7 %

[1] Percentage by mass of N in NH_4NO_3 = [2(14) / 80] x 100 = 35.0%

A small number of students did not read the question carefully and did not calculate **percentage by mass**.

Many students gave working with no statements to show what the calculations were for.

(ii) Urea is manufactured by the reaction as shown.

$$2NH_3 + CO_2 \rightarrow CO(NH_2)_2 + H_2O$$

Calculate the mass of urea produced when 50 g of ammonia is reacted with 30 dm^3 of carbon dioxide. [3]

no. of moles of ammonia = 50 / 17 = 2.941 mol

no. of moles of carbon dioxide = 30 / 24 = 1.25 mol

CO_2 is the limiting reagent

[1] show both mole calculations

[1] No. of moles of urea = no. of moles of carbon dioxide

Mr of urea = 60

[1] Mass of urea = 1.25 x 60 = 75.0 g

- Data is given for both reactants – NH_3 and CO_2.
- Many students did not use both sets of data to determine the limiting reagent.
- A significant number of students incorrectly calculated the Mr of ammonia as 2 x (14 + 3).
- Working with no clear statements what the calculations were for.

(c) Table 4.1 shows two oxides of nitrogen.

Table 4.1

oxide	chemical formula	type of oxide			
		neutral	acidic	basic	amphoteric
nitrogen monoxide	NO	✓			
nitrogen dioxide	NO_2		✓		

(i) Write the chemical formula of the two oxides of nitrogen in Table 4.1. [1]

[1] Both correct

(ii) Identify the type of oxide by ticking (✓) the appropriate boxes in in Table 4.1 [2]

[Total: 12]

A5 Chlorine and bromine are halogens found in Group VII of the Periodic Table. They show a trend in their physical and chemical properties..

(a) Complete Table 4.1 to show the properties of chlorine and bromine. [2]

Table 5.1

halogen	physical state at room temperature and pressure	colour
chlorine	**gas**	**greenish-yellow**
bromine	**liquid**	**red-brown**

Only a handful of students were able to correctly state the physical state and colour of the halogens.

(b) When chlorine is added to an aqueous solution of potassium bromide, a reaction occurs.

(i) State the observations for this reaction. [1]

Colourless solution turns red-brown

(ii) Explain the reaction that has occurred. [2]

[1] Chlorine is more reactive than bromine

[1] chlorine displaces bromine from bromide solution

Some students explained that the displacement reaction produced potassium chloride (which is correct) but did not mention production of bromine which explains the observation of solution turning red-brown.

(iii) Write a balanced **ionic** equation, with state symbols, for the reaction. [2]

Cl_2 (aq) + $2Br^-$ (aq) → $2Cl^-$ (aq) + Br_2 (*l*)

[1] correct formulae

[1] correct state symbols
A: (g) for Cl_2, (aq) for Br_2

Some students gave chemical equations instead of ionic equations.

Many gave incorrect formula for chlorine and bromine, and forgot the charges for the chloride and bromide ions.

(c) Chlorine reacts with bromine to form bromine chloride as shown by the chemical equation.

$$Cl_2 + Br_2 \rightarrow 2BrCl$$

The table shows the bond energies.

	Cl–Cl	Br–Br	Br–Cl
bond energy in kJ/mol	244	193	204

(i) Use the data in the table to calculate the

- energy for bond breaking [1]

  energy for bond breaking = 244 + 193 = 437 kJ / mol

- energy for bond making [1]

  energy for bond making = 2 x 204 = 408 kJ / mol

(ii) Hence calculate the enthalpy change of the reaction. [1]

ΔH = 437 – 408 = + 29 kJ / mol

Missing units, and positive sign for enthalpy change of reaction.
1 mark overall deducted.

[Total: 10]

A6 **K** is a mixture of compounds **L** and **M**.

Fig. 6.1 is a flowchart that shows a series of chemical reactions carried out on **K**.

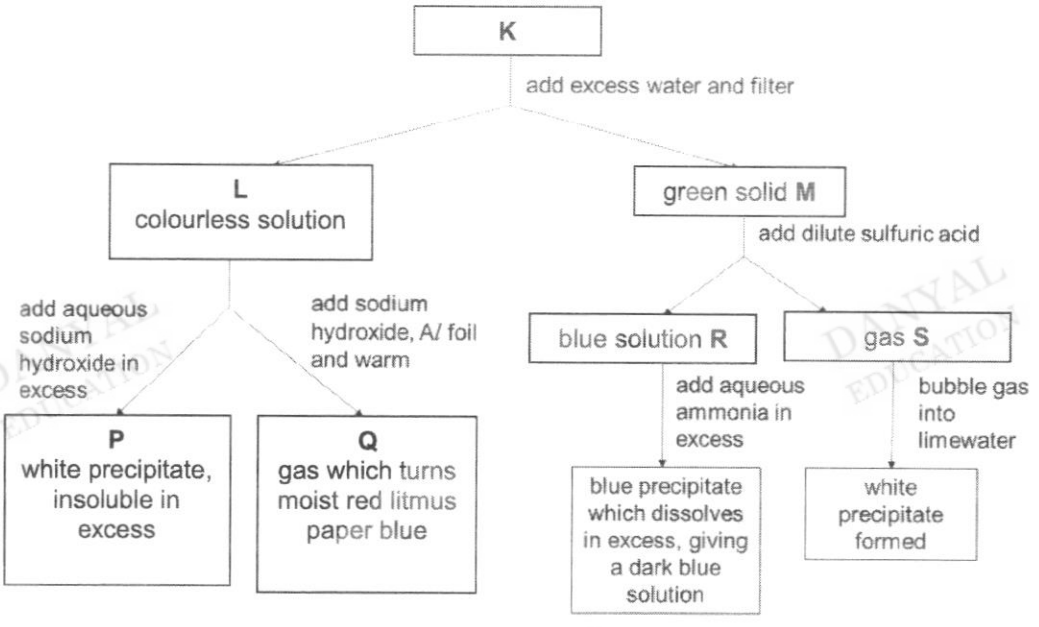


Fig 6.1

(a) Identify **L**, **M**, **P**, **Q**, **R** and **S**. [6]

L calcium nitrate / $Ca(NO_3)_2$

M copper(II) carbonate / $CuCO_3$

P calcium hydroxide / $Ca(OH)_2$

Q ammonia / NH_3 (g)

R copper(II) sulfate / $CuSO_4$

S carbon dioxide / CO_2 (g)

(b) Write a balanced chemical equation for any **one** of the reactions above. [2]

[1] correct chemical formula
[1] balanced

[Total: 8]

Section B

Answer all **three** questions in the spaces provided.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B6 Acids have many uses in industries. One example is sulfuric acid which is commonly used as industrial cleaners and for the manufacture of other chemicals. Sulfuric acid is a strong acid that is produced on a large scale, with an annual world production of 230 million tonnes. One method to manufacture sulfuric acid is known as the *Wet Sulfuric Acid Process*, as shown in the following steps:

step 1 Hydrogen sulfide, H_2S, is burned in oxygen to produce sulfur dioxide and water.

step 2 The sulfur dioxide produced then reacts with more oxygen to form sulfur trioxide.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 \qquad \Delta H = -198 \text{ kJ / mol}$$

step 3 Sulfur trioxide is then dissolved in water to produce sulfuric acid.

$$SO_3 + H_2O \rightarrow H_2SO_4 \qquad \Delta H = -191 \text{ kJ / mol}$$

Besides industrial uses, acids are also commonly found in food and beverages. Orange juice contains citric acid which contributes a sour taste. The amount of citric acid present in orange juice determines the sourness of the juice. The concentration of citric acid, H_3A, can be determined by titration with an alkali. The chemical equation for the reaction between citric acid and sodium hydroxide is as shown.

$$H_3A\,(aq) + 3NaOH\,(aq) \rightarrow Na_3A\,(aq) + 3H_2O\,(l)$$

(a) **(i)** Write a balanced chemical equation for the reaction in step 1. [2]

$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$
[1] correct formula
[1] balanced – many forgot to balance the equation

(ii) Draw a 'dot and cross' diagram to show the bonding in H_2S. Show only the valence electrons. [2]

[1] correct number of valence electrons for each atom
[1] correct pairs of shared electrons

A significant number of students thought this was an ionic compound.

(b) (i) Explain, in terms of oxidation states, whether step 2 is a redox reaction. [2]

[1] S in SO_2 oxidised as o.s increased from +4 to +6 in SO_3

[1] O in O_2 reduced as o.s. decreased from 0 to -2 in SO_3/H_2O

Redox because there is oxidation and reduction in the same reaction.

Some students omitted to link the increase in O.S. to oxidation and vice-versa.
Many incorrectly determined the O.S. of oxygen in SO_3 to be -6.

(ii) On Fig 6.1, draw an energy profile diagram of the reaction in step 2. Your diagram should show and label
- the reactants and products
- the activation energy and enthalpy change of reaction. [3]

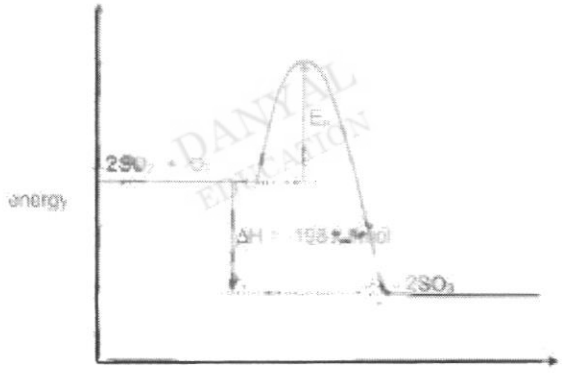


Fig. 6.1

[1] correct energy level for reactants and products (with labels)
[1] correct arrow direction for E_a and label
[1] correct arrow direction for ΔH and label

(c) A sample of bottled orange juice was tested in a laboratory to determine the concentration of citric acid present. 10 cm^3 sample of orange juice was diluted to 100 cm^3 with distilled water. 25.0 cm^3 of the diluted solution required 30.50 cm^3 of 0.0100 mol/dm^3 sodium hydroxide for complete reaction.

(i) Calculate the number of moles of citric acid present in the 10 cm^3 sample of orange juice. [2]

No. of moles of NaOH = (30.50/1000) x 0.0100 = 3.05×10^{-4} mol

No. of moles of citric acid in 25.0 cm^3 of diluted solution
= $\frac{3.05 \times 10^{-4}}{3}$ = 1.017×10^{-4} mol

(100 cm^3 of diluted sample was made from 10 cm^3 sample of orange juice)

No. of moles of citric acid present in sample = 1.017×10^{-4} x (100 / 25.0)
= 4.07×10^{-4} mol

Of the students who attempted this question, many forgot to account for the dilution of the 10 cm^3 sample and that only 25.0 cm^3 of the diluted solution was titrated.

(ii) Hence calculate the concentration of citric acid present in the orange juice. [1]

concentration of citric acid in juice = 4.067×10^{-4} x (1000 / 10)
= 0.0407 mol / dm^3

[Total: 12]

B7 (a) Suggest the reagents and steps required to prepare a pure sample of magnesium chloride. [4]

[1] correct reagents (any of the following):
- **Mg metal + hydrochloric acid**
- **magnesium carbonate + hydrochloric acid**
- **magnesium oxide + hydrochloric acid**

[1] excess of solid

[1] correct separation technique:
- **filter and retain filtrate**

[1] correct purification technique:
- **heat filtrate to obtain saturated solution, leave to cool**
- **filter crystals, wash with small amount of cold water**
- **leave to dry or dry between sheets of filter paper**

(b) **(i)** Write a balanced chemical equation for the reaction you have chosen in **(a)**. [2]

[1] correct formula

[1] balanced

(ii) Draw a 'dot-and-cross' diagram of magnesium chloride.
Show only the valence electrons. [2]

[1] correct number of electrons for each ion

[1] correct charge for cation and anion AND shows 2 anions
Accept '2' written in front of 1 anion diagram

Quite a few students thought magnesium chloride is a covalent compound

[Total: 8]

EITHER

B8 **(a)** Carbon nanotubes were first discovered in 1952 by two Russian scientists. It is an allotrope of carbon with a diameter that is about one-thousandth of the thickness of a human hair.

The structure of the different carbon allotropes are shown in Fig 8.1.

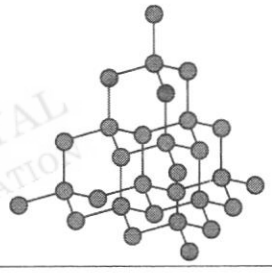
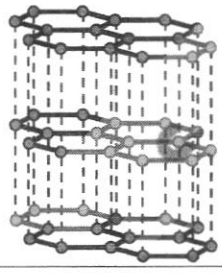
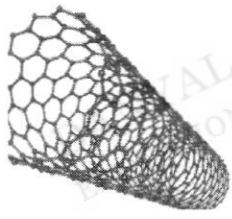
allotropes of carbon		
		
diamond	graphite	carbon nanotube

Fig. 8.1

(i) Explain, in terms of structure and bonding, why carbon nanotubes can withstand high temperatures up to 750 °C. [2]

[1] giant covalent lattice structure

[1] A lot of energy required to overcome the strong covalent bonds in the three-dimensional lattice

Students either forgot to state the structure or gave the "shape" (e.g. hexagonal) instead of structure.

(ii) Carbon nanotubes are also good electrical conductors. Explain this property in terms of its bonding. [2]

[1] each C atom is bonded to 3 other C atoms

[1] 1 valence electron not used for bonding, can move freely / mobile to conduct electricity

Many students did not indicate that it is the valence electron that is delocalised.

(b) Many materials that we use in daily life contain carbon. Plastic bags are very large molecules made from smaller hydrocarbon molecules.

Hydrocarbon molecules contain only carbon and hydrogen atoms.
One such hydrocarbon, **X**, contains 85.7% by mass of carbon atoms.

The relative molecular mass of **X** is 28.

(i) Calculate the empirical formula of **X**. [3]

	C	H
% mass	85.7	100 – 85.7 = 14.3
no. of moles	7.14	14.3
mole ratio	1	2

[1] Empirical formula is CH_2

[1] correct calculation of % mass of H

[1] correct calculation of moles

(ii) Hence determine the molecular formula of **X**. [1]

n (12 + 2) = 28

n = 2

[1] Molecular formula is C_2H_4.

(iii) Based on your answer in **(ii)**, explain why **X** exists as a gas at room temperature and pressure. [2]

[1] Simple covalent molecule

[1] <u>Little energy</u> required to overcome the <u>weak intermolecular forces of attraction</u> between C_2H_4 molecules.

[Total: 10]

OR

B8 **(a)** An element **Y** burns in oxygen to form a compound, Y_2O_3, which has a relative molecular mass of 160.

(i) Determine the identity of element **Y**. [2]

2(Ar of Y) + 3(16) = 160

[1] Ar of Y = 56

[1] Y is iron.

(ii) Explain, in terms of structure and bonding, if element **Y** can conduct electricity. [2]

[1] metallic lattice structure

[1] metal cations in 'sea of electrons' which can move freely/ mobile to conduct electricity

(iii) State if the compound Y_2O_3 has a low or high melting point. Explain your answer. [2]

High melting point

[1] a lot of energy required to overcome strong

[1] electrostatic forces of attraction / ionic bonds between ions

(b) Many organic molecules contain oxygen. One example is compound **Z** which has the following composition by mass:

C, 40.0%; H, 6.7%; O, 53.3%.

The relative molecular mass of **Z** is 180.

(i) Calculate the empirical formula of **Z**. [3]

	C	H	O
% mass	40.0	6.7	53.3
no. of moles	3.33	6.7	3.33
mole ratio	1	2	1

[1] Empirical formula is CH_2O

[1] correct calculation of moles

[1] correct calculation of mole ratio

(ii) Hence determine the molecular formula of **Y**. [1]

n (12 + 2 + 16) = 180

n = 6

[1] Molecular formula of Y is $C_6H_{12}O_6$

[Total: 10]

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