End-of-Year Examination 2022
Secondary Three Express
Chemistry
Paper 1 (6092/1)

Date of Examination: 12 October 2022 **Duration: 1 hour**

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Name : _____( ) Class : Sec 3 /_____

Instructions to Candidates

Write your name, index number and class on the answer sheet provided.
Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

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 Optical Answer Sheet **(OAS)**.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done on this paper.
A copy of the Periodic Table is printed on page 18.
The use of an approved scientific calculator is expected, where appropriate.

Paper	Marks
1	40

This Paper consists of **18** printed pages, including the cover page.

1 A student follows the rate of the reaction when 0.2 g of magnesium, Mg reacts with excess sulfuric acid, H_2SO_4 at room temperature and pressure.

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

What is most suitable for measuring the volume of gas produced at different times during this experiment?

A a 50 cm^3 gas syringe

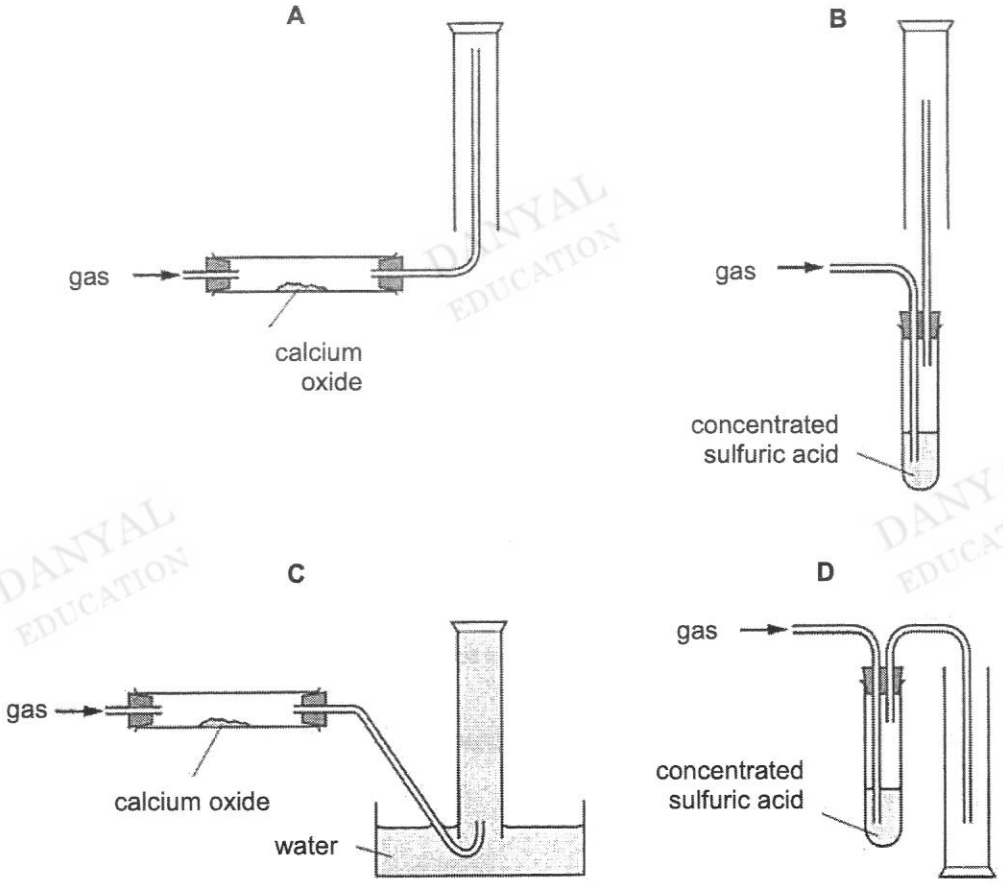
B an inverted 250 cm^3 measuring cylinder filled with water

C an inverted 50 cm^3 burette filled with water

D place the apparatus on a balance and measure the loss in mass

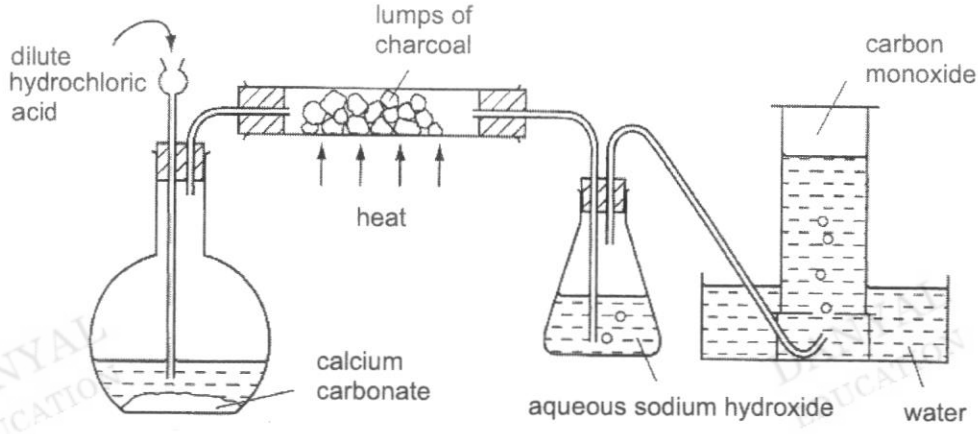
2 A gas turns moist blue litmus paper red, is insoluble in water and less dense than air.

Which diagram shows a correct way of drying and collecting the gas?



3 The diagram shows apparatus used to obtain carbon monoxide. Carbon dioxide produced reacts with charcoal according to the following equation.

$$CO_2 + C \rightarrow 2CO$$



What is the purpose of the aqueous sodium hydroxide?

A to dry the gas

B to remove hydrogen chloride from the gas

C to remove carbon dioxide from the gas

D to prevent water from being sucked back onto the hot carbon

4 A colourless substance is made in an experiment.

Which are possible methods to determine if this substance is pure?

1 Measure the melting point of the substance and compare with the reference value.
2 Measure the boiling point of the substance and compare with the reference value.
3 Test the substance using paper chromatography and a locating agent.

A 3 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

5 Potassium nitrate crystals can be separated from sand using the four processes shown below.

Which of the following shows the processes in the correct order?

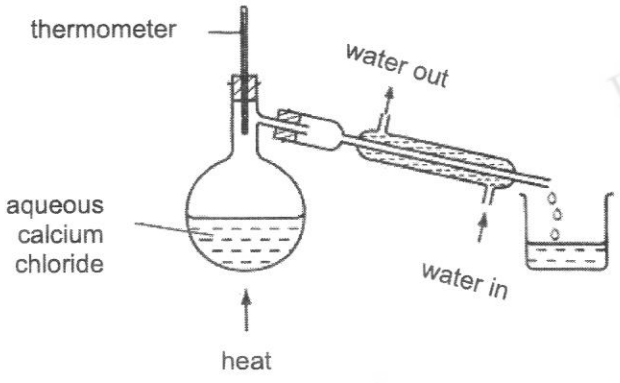
A filter, dissolve, evaporate, crystallise

B dissolve, evaporate, crystallise, filter

C dissolve, crystallise, filter, evaporate

D dissolve, filter, evaporate, crystallise

6 An aqueous solution of calcium chloride is distilled.



Which of the following correctly describes the temperature shown by the thermometer during distillation and the final contents in the distillation flask at the end of the distillation?

	thermometer reading / °C	final contents of the distillation flask
A	98	no residue
B	100	no residue
C	100	white residue
D	98	white residue

7 Calcium reacts with cold water to form two products:

- a colourless gas, P, which 'pops' with a lighted splint
- a weakly alkaline solution, Q, which forms a white precipitate when carbon dioxide is bubbled through it

What is P and Q?

	P	Q
A	oxygen	hydrochloric acid
B	hydrogen	limewater
C	ammonia	aqueous ammonia
D	carbon dioxide	carbonic acid

8 A colourless solution X is tested separately with aqueous sodium hydroxide and with aqueous silver nitrate.

The observations are shown.

test	add aqueous sodium hydroxide	add dilute nitric acid followed by aqueous silver nitrate
observations	white precipitate insoluble in excess	white precipitate

What is X?

A calcium chloride

B calcium sulfate

C zinc chloride

D zinc sulfate

9 Gas Z is soluble in water. Its solution turns red litmus paper blue.

Which statement is **not** correct?

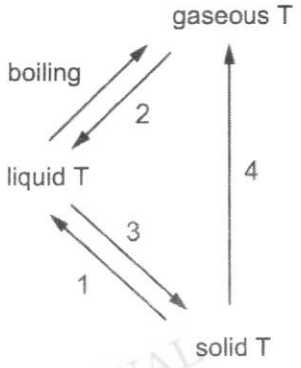
A A green precipitate is obtained when an aqueous solution of Z is added to aqueous iron(III) nitrate.

B A white precipitate is produced, which then dissolves when an aqueous solution of Z is added to aqueous zinc nitrate.

C Gas Z could be made by warming ammonium nitrate with aqueous sodium hydroxide.

D Gas Z could be made by warming calcium nitrate with aqueous sodium hydroxide and powdered aluminium.

10 Element T can undergo the following physical changes.



Which process/processes involve(s) particles increasing in energy?

A 1 only

B 1 and 2 only

C 2 and 3 only

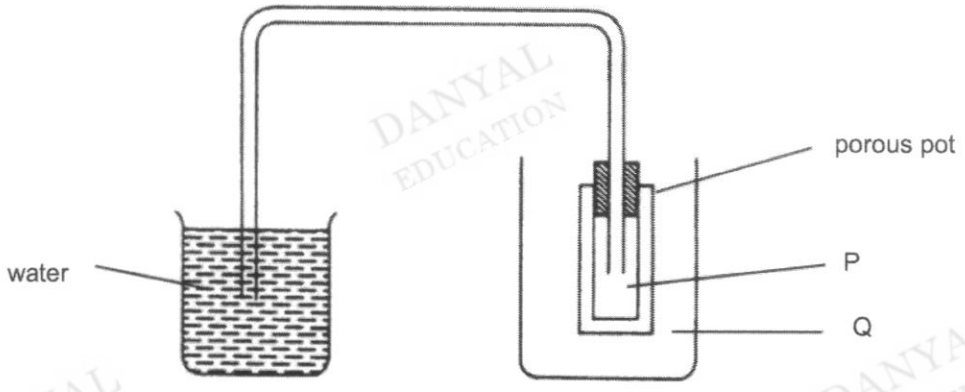
D 1 and 4 only

11 The diagram shows the arrangement of particles in a substance at different temperatures.

Which of the following could the substance be?

substance	melting point / °C	boiling point / °C
A	–147	–24
B	–147	–28
C	–144	–24
D	–144	–28

12 An experiment was set up to investigate the rate of diffusion of two gases P and Q.



Bubbles of gas were observed in the beaker of water.

Which conclusion is correct?

A P has higher relative molecular mass than Q.

B P is monoatomic and Q is diatomic.

C P is an unreactive gas and Q is a reactive gas.

D P diffuses out of the tube faster than Q diffuses into the porous pot.

13 The ion Q^{2+} has three complete shells of electrons.

What is Q?

A calcium

B magnesium

C oxygen

D sulfur

14 The symbols for two ions are shown.

$$^{19}_{9}F^{-} \qquad ^{21}_{11}Na^{+}$$

Which statement is correct?

A The fluoride ion contains more electrons than the sodium ion.

B The sodium ion contains more neutrons than the fluoride ion.

C Both ions contain the same number of electrons.

D Both ions contain the same number of protons.

15 The relative atomic mass of naturally occurring chlorine is not a whole number.

What is the reason for this?

A Chlorine atoms can have different numbers of neutrons.

B Chlorine is unstable.

C Naturally occurring chlorine cannot be obtained pure.

D The mass of the electrons has been included.

16 Element X forms an acidic oxide.

How many electrons could possibly be in the outer shell of atom X?

	1 electron	2 electrons	6 electrons	7 electrons
A	✓	✓	×	×
B	✓	×	✓	×
C	×	×	✓	✓
D	×	✓	×	✓

17 The following are labels that describe the contents of four different bottles.

contents of bottle W white colour, soluble in water	contents of bottle X when burnt in air, forms carbon dioxide and water
contents of bottle Y green colour melts between 48 – 50°C	contents of bottle Z when burnt in air, only water is formed

The contents of each bottle can be either elements, compounds or mixtures.

Which of the following shows the correct classification of the bottles?

	W	X	Y	Z
A	compound	mixture	compound	compound
B	compound	compound	element	element
C	element	element	mixture	compound
D	element	compound	mixture	element

18 Which statement(s) correctly describe(s) the properties of mixtures of iron and sulfur, and the compound iron(II) sulfide, FeS?

	mixtures of iron and sulfur	compound iron(II) sulfide
1	Iron and sulfur mix without chemically reacting.	Iron and sulfur combine in a chemical reaction to form iron(II) sulfide.
2	The ratio of iron to sulfur in mixtures can vary.	The ratio of iron to sulfur in iron(II) sulfide is always the same.
3	The mixtures do not have the properties of iron or sulfur.	Iron(II) sulfide has the properties of iron and sulfur.

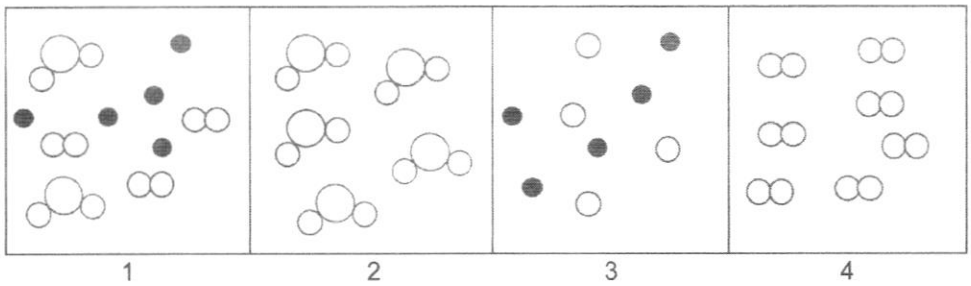
A 1 only

B 1 and 2 only

C 2 and 3 only

D 3 only

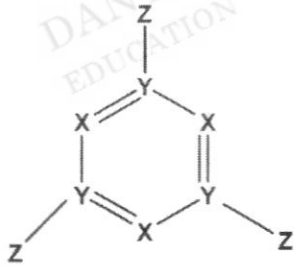
19 The diagrams show the arrangement of particles in four substances.



Which of the following shows the correct description of the substances?

	molecules of an element	molecules of a compound	mixture of elements	mixture of elements and compounds
A	2	4	3	1
B	2	4	1	3
C	4	2	3	1
D	4	2	1	3

20 A molecule containing atoms of the elements X, Y and Z has the following structure.



Which is a possible combination of the elements?

	X	Y	Z
A	C	O	H
B	N	C	H
C	O	C	*Cl*
D	N	O	*Cl*

21 What is the formula of iron(III) nitrate?

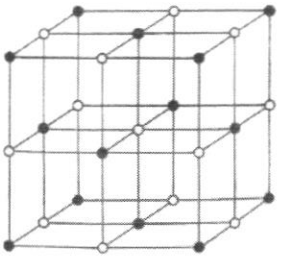
A FeN

B FeN_3

C $FeNO_3$

D $Fe(NO_3)_3$

22 The diagram shows the structure of a substance.



Which substance has this structure?

A silicon dioxide

B potassium iodide

C graphite

D diamond

23 Which particles are responsible for the conduction of electricity through a metal?

A electrons only

B electrons and positive ions

C negative ions only

D negative ions and positive ions

24 Magnesium chloride crystallises as a hydrate, $MgCl_2.xH_2O$. When 20.3 g of the hydrate was heated to a constant mass, 9.5 g of the anhydrous salt remained.

What is the value of x?
[M_r: $MgCl_2$, 95.0; H_2O, 18.0]

A 2

B 6

C 8

D 10

25 On heating, the carbonate of element Y decomposes.

$$YCO_3(s) \rightarrow YO(s) + CO_2(g)$$

6.25 g of YCO_3 is heated and 1.2 dm^3 of carbon dioxide, measured at room temperature and pressure, is produced.

What is the relative atomic mass, A_r, of Y?

A 57

B 65

C 125

D 150

26 Zinc reacts with hydrochloric acid.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

1.0 mol of zinc was added to 1.0 mol of hydrochloric acid.

Which of the following represents the amounts of zinc, hydrochloric acid and zinc chloride at the end of the reaction?

	Zn	HCl	$ZnCl_2$
A	1.0 mol	0 mol	1.0 mol
B	0 mol	0.5 mol	0.5 mol
C	0.5 mol	0 mol	0.5 mol
D	0 mol	0 mol	1.0 mol

27 Iron is extracted from iron ore that contains Fe_2O_3 by reacting it with carbon monoxide in a furnace according to the chemical equation.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

600 g of iron ore produces 82 g of iron.

What is the percentage purity of iron ore ?
[A_r: Fe, 56.0; O, 16.0]

A 6.8%

B 13.7%

C 19.5%

D 39.0%

28 Turmeric is an example of a natural indicator. It forms a yellow solution in water. This solution turns red when an alkali or base is added but remains yellow if an acid is added.

Turmeric solution is added to a sample of liquid soap, pH 8, and to vinegar, pH 3.

What colours are observed?

	liquid soap	vinegar
A	red	red
B	red	yellow
C	yellow	red
D	yellow	yellow

29 An unknown metal oxide, XO, is an insoluble solid.

XO is a basic oxide.

Which row is correct?

	effect of adding universal indicator to solid XO	reaction of XO with sodium hydroxide	reaction of XO with hydrochloric acid
A	no change	✓	×
B	no change	×	✓
C	turns blue	✓	×
D	turns blue	×	✓

30 When dilute sulfuric acid is added to solid Y, a colourless solution is formed and a gas is produced.

What is Y?

A copper(II) oxide

B sodium oxide

C copper(II) carbonate

D sodium carbonate

31 Salts are made by reacting acids with bases.

For which combination of acids and bases is the titration method of preparation suitable?

A an insoluble acid with an insoluble base

B an insoluble acid with a soluble base

C a soluble acid with an insoluble base

D a soluble acid with a soluble base

32 When liquids R and S are mixed, a solution with a pH value of 7 is formed.

Which of the following are the pH values of the two liquids?

	R	S
A	5	2
B	5	12
C	6	1
D	14	7

33 Which of the following reactions could be represented by the ionic equation below in which M is the symbol for a metallic element?

$$M\,(s) + 2H^+\,(aq) \rightarrow M^{2+}\,(aq) + H_2\,(g)$$

A iron and hydrochloric acid

B lead and sulfuric acid

C copper and nitric acid

D sodium and water

34 Which substances produce an insoluble salt when aqueous solutions of the substances are mixed?

A barium chloride and magnesium nitrate

B calcium chloride and ammonium nitrate

C silver nitrate and zinc chloride

D sodium carbonate and potassium sulfate

35 What reacts with dilute hydrochloric acid to make magnesium chloride?

1 magnesium

2 magnesium carbonate

3 magnesium oxide

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

36 The table shows data for atoms or ions of the elements P, Q, R and S. The letters do not represent the chemical symbols of the elements.

	number of electrons	number of protons
P	10	11
Q	13	13
R	18	17
S	18	18

Which statement is correct?

A P and Q are non-metallic.

B P and R react to form an ionic compound.

C Q and S are unreactive.

D R and S would be in the same group of the Periodic Table.

37 Arc welding is a process which uses electricity to make high temperatures to melt two pieces of metals so that they can be joined.

Argon is blown onto the surface where the molten metals are joining.

Why is argon used?

A It reacts with oxygen, releasing heat which helps the metals to melt.

B It gives off a lot of light to help the welder see what they are doing.

C It is a good electrical conductor and so creates a high temperature.

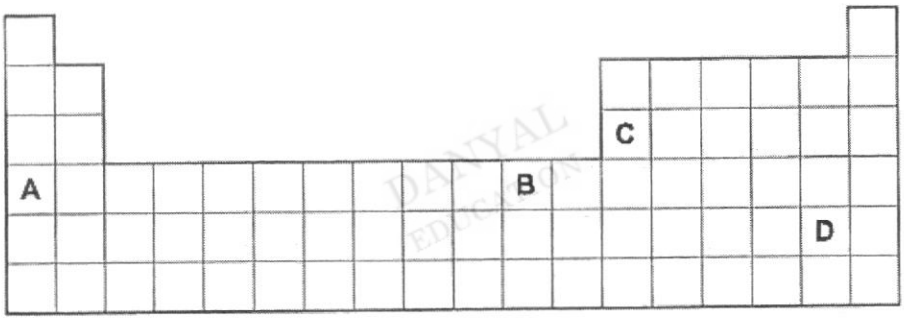
D It is an inert gas and so prevents the metals from reacting with unwanted substances.

38 An ionic chloride of element Z has the formula ZC*l*.

When ZC*l* is added to water and swirled, a coloured solution appears. The formula of the coloured solution is ZCl_2.

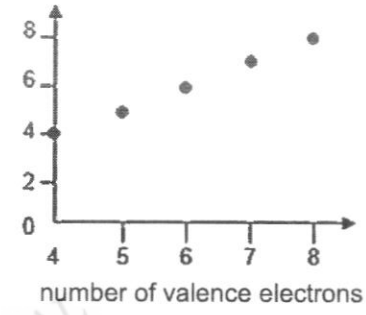
The diagram shows part of the Periodic Table.

Which letter identifies element Z?

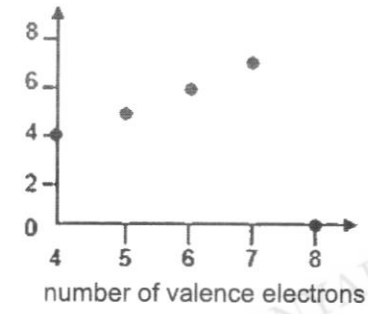


39 Which diagram best represents the relationship between the number of valence electrons in an atom and the number of hydrogen atoms that can combine with the atom to form a stable compound?

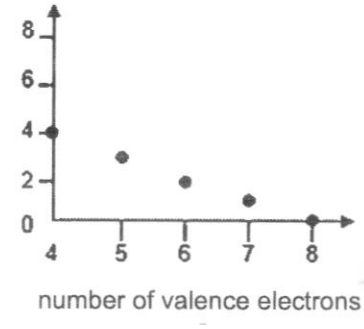
A



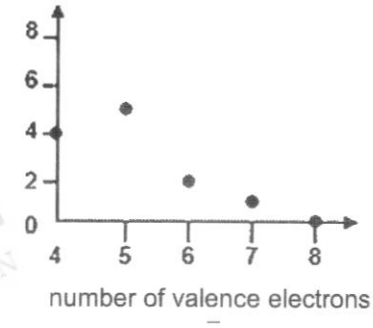
B



C



D



40 Element X forms an oxide of formula X_2O_5.

In which group of the Periodic Table is X likely to be found?

A Group II

B Group III

C Group V

D Group VIII

END OF PAPER 1

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										2 He helium 4
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
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 –		

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 dm^3 at room temperature and pressure (r.t.p.).

End-of-Year Examination 2022
Secondary Three Express
Chemistry
Paper 2 (6092/2)

Date of Examination: 6 October 2022 **Duration: 1 hour 30 minutes**

Name : _____( ) Class : Sec 3 / _____

Instructions to Candidates

Write your name, index number and class in the spaces provided on all the work you hand in.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A and Section B
Answer **all** questions in the spaces provided on the question paper.

At the end of the examination, 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 16.

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

Section	Marks
A	45
B	20
Total	65

This Paper consists of **16** printed pages, including the cover page.

Section A

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

A1 Table 1.1 shows the names and symbols of some isotopes of common elements.

Table 1.1

isotope name	fluorine-19	carbon-12	iodine-131	strontium-90	neon-20	carbon-14	magnesium-24
isotope symbol	$^{19}_{9}F$	$^{12}_{6}C$	$^{113}_{53}I$	$^{90}_{38}Sr$	$^{20}_{10}Ne$	$^{14}_{6}C$	$^{24}_{12}Mg$

(a) Define the term *isotopes*.

.....

..... [2]

(b) Use the isotopes in Table 1.1 to answer the following questions.

(i) Name two isotopes that contain the same number of protons in each of their atoms.

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

(ii) Name two isotopes that contain the same number of neutrons in each of their atoms.

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

(iii) Name two isotopes that form compounds that contain ions with a charge of +2.

.....and .....

(iv) Name two isotopes that exist as diatomic molecules.

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

[Total : 6 m]

A2 Ephedrine and insulin are both drugs that are banned for use by athletes. One way that athletes can be tested for the banned drugs is by chromatography of urine samples. Fig. 2.1 shows a chromatogram for ephedrine and insulin, and the urine samples from four athletes.

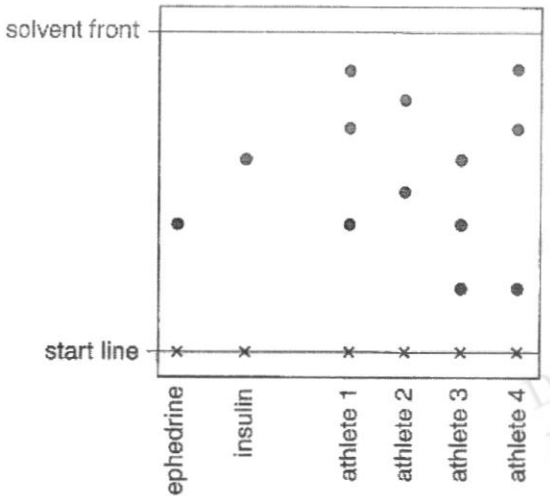


Fig. 2.1

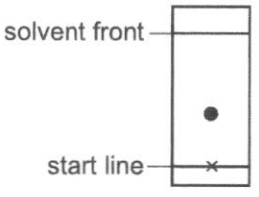
(a) What does the chromatogram show about the drugs used by each of the athletes?

.....

.....

..... [2]

(b) A similar test was carried out on the urine of a fifth athlete. This diagram shows the chromatogram for the fifth athlete.



Show, by using R_f values, if this athelete had consumed any drugs.

[3]

[Total : 5 m]

A3 Table 3.1 shows the melting points and boiling points of Group I and Group VII elements.

Table 3.1

	element	melting point/ °C	boiling point/ °C
Group I	lithium	180	1330
	sodium	97.8	890
	potassium	64	774
Group VII	chlorine	−101	−35
	bromine	−7	59
	iodine	114	184

(a) The trends in melting points and boiling points for elements in Group I differ from those in Group VII.

Describe the trends down each group.

.....

.....

..... [2]

(b) An experiment was carried out by adding halogens **A**, **B** and **C** to each of the halide solutions. The results of the experiment are shown in Table 3.2.

A tick (✓) indicates a reaction. A cross (x) indicates no reaction.

Table 3.2

	halide solution of **A**	halide solution of **B**	halide solution of **C**
A		✓	x
B	x		x
C	✓	✓	

(i) Based on the results, arrange **A**, **B** and **C** in increasing order of reactivity.

..... [1]

(ii) Identify halogens **A**, **B** and **C** from Table 3.2.

A: ..... **B**: ..... **C**: ..... [1]

(c) Sea water contains potassium bromide.

Name an element that can be added to sea water to produce bromine and write a balanced chemical equation for the reaction.

.....

..... [2]

[Total : 6 m]

A4 Industry transforms millions of tons of air, natural gas and mined ores into products based on the three essential plant nutrients nitrogen, phosphorus and potassium.

(a) The bags of ammonium nitrate fertiliser have the following printed on them.

Do not add fertiliser to soil that has been recently treated with any calcium hydroxide

Give reasons why it is important not to add ammonium compounds to soils that have been recently treated with calcium hydroxide.

.....

.....

.....

..... [2]

(b) Phosphate ions, PO_4^{3-}, are present in the waste water from the factory. One way of treating the water to remove these phosphate ions is by adding calcium ions.

The calcium ions react with the phosphate ions to form a precipitate.

(i) Write an ionic equation, with state symbols, to show the reaction between calcium ions and phosphate ions.

..... [2]

(ii) The waste water also contains nitrate ions.
Explain why nitrate ions cannot be removed by precipitation reactions.

.....

..... [1]

[Total : 5 m]

A5 Silver dichromate, $Ag_2Cr_2O_7$, is a red insoluble salt.

Silver dichromate can be made by reacting silver nitrate solution with ammonium dichromate solution. The chemical equation for the reaction is shown.

$$2AgNO_3\,(aq) + (NH_4)_2Cr_2O_7\,(aq) \rightarrow Ag_2Cr_2O_7\,(s) + 2NH_4NO_3\,(aq)$$

(a) The salt was prepared from solid samples of silver nitrate and ammonium dichromate. The apparatus shown was set up.

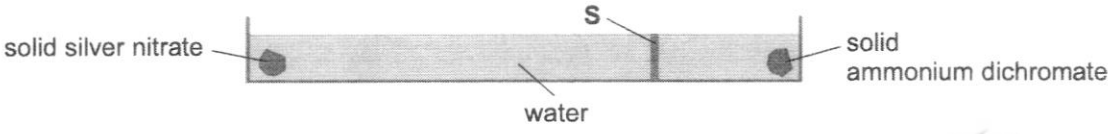


Fig. 5.1

(i) Determine the formula of the dichromate anion.

..... [1]

(ii) Explain why the red solid appeared along the line marked **S** on Fig. 5.1.

.....

.....

..... [2]

(iii) The experiment was repeated at a higher temperature.

What effect would this have on the time taken for the red solid to appear? Explain your answer.

.....

..... [1]

(b) Describe how you could obtain pure dry solid silver dichromate from the reaction mixture.

.....

.....

..... [2]

[Total : 6 m]

A6 Dilute ethanoic acid and dilute hydrochloric acid were reacted with sodium carbonates separately.

(a) (i) Describe one similarity in the observations in both reactions.

Explain your answer.

....

....

.... [2]

(ii) Describe one difference in the observations in both reactions.

Explain your answer.

....

....

.... [2]

(b) Fig. 6.1 describes some of the substances that result from the chemical reactions of dilute hydrochloric acid.

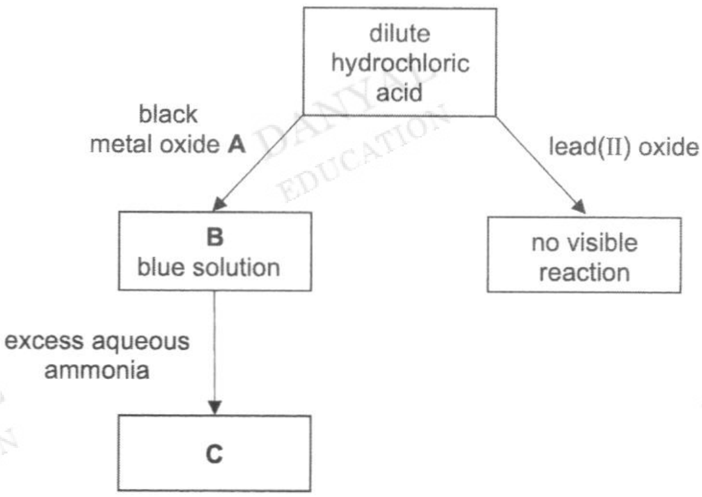


Fig. 6.1

(i) Suggest the identity of substances **A** and **B**.

A ....

B .... [2]

(ii) Describe what will be observed at **C**.

....

.... [2]

(iii) Explain why there is no visible reaction when lead(II) oxide is added to hydrochloric acid.

.....

.....

..... [1]

[Total : 9 m]

A7 A student carried out a titration between dilute sulfuric acid and sodium hydroxide solution to determine the concentration of dilute sulfuric acid. Fig. 7.1 shows his results from the experiment.

<u>**Titration**</u>

Chemical Equation:

$$2NaOH(aq) \quad + \quad H_2SO_4(aq) \quad \rightarrow \quad Na_2SO_4(aq) \quad + \quad 2H_2O(l)$$

Concentration of sodium hydroxide – 2.00 mol/dm^3

<u>**Method**</u>

Step 1 - Pipette 25.0 cm^3 of 2.00 mol/dm^3 sodium hydroxide solution into a conical flask.
Step 2 - Add 2 or 3 drops of screened methyl orange indicator.
Step 3 - Add dilute sulfuric acid into a burette, record the initial volume of dilute sulfuric acid in the table below.
Step 4 - Add dilute sulfuric acid from the burette into the sodium hydroxide solution until the reaction is complete. Record the final volume of dilute sulfuric acid in the table below.

<u>**Results**</u>

Final volume of dilute sulfuric acid / cm^3	19.10
Initial volume of dilute sulfuric acid / cm^3	0.40

Fig. 7.1

(a) Calculate the volume, in cm^3, of dilute sulfuric acid used.

volume = ... cm^3 [1]

(b) Calculate the concentration, in mol/dm^3, of dilute sulfuric acid.

concentration = ... mol/dm^3 [2]

(c) Explain why washing the burette with deionised water before Step 3 will result in a larger volume of sulfuric acid needed for the reaction to be complete.

.....

.....

..... [2]

(d) Sodium hydroxide is a strong alkali that contains a hydroxide ion. The hydroxide ion contains a covalent bond between the oxygen and hydrogen atoms. Both atoms in the ion have a full valence shell of electrons because the ion also has an overall negative charge.

$[O–H]^-$

hydroxide anion

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

[1]

(ii) State and explain the electrical conductivity of sodium hydroxide in solid and aqueous states.

.....

.....

.....

..... [2]

[Total : 8 m]

Section B

Answer **all** questions.
Write your answers in the spaces provided.

B8 **Ideal and Real Gases**

An ideal gas is a hypothetical gas composed of many randomly moving gas particles that do no exert any intermolecular forces of attraction between each other. While no gas on Earth behaves completely like an ideal gas and are therefore called "real gases", the ideal gas concept is an important assumption to make in order for scientist to predict various properties of gases.

One such property is the molar volume of gases. The molar volume of an ideal gas at room temperature and atmospheric pressure is 24.0 dm^3. This volume is derived based on Charles's law, which describes how the volume of one mole of ideal gas changes with respect to temperature.

The molar volume of an ideal gas at temperatures between –215 °C and –180 °C is shown in Fig. 8.1. At the same temperature, the volume of real gases deviates from ideal gases. The volume of one mole of hydrogen gas, nitrogen gas and chlorine gas at different temperatures are also shown in Fig. 8.1.

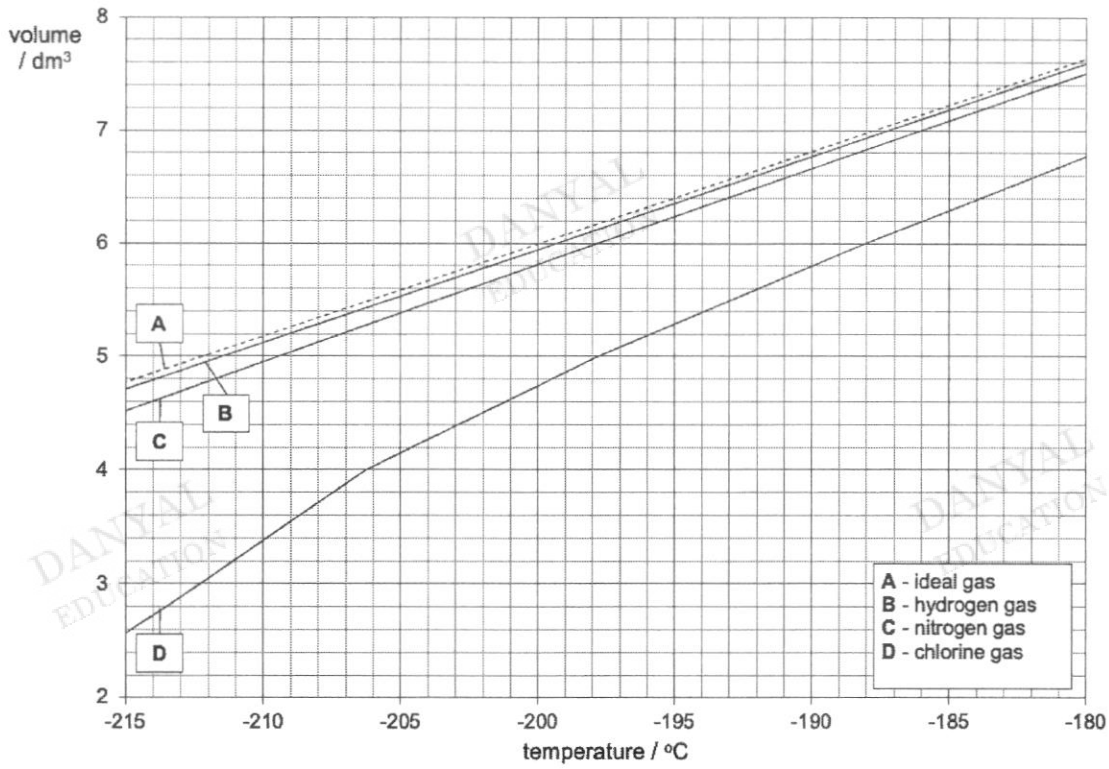


Fig. 8.1

(a) **(i)** Based on Fig. 8.1, describe the relationship between temperature and the molar volume of an ideal gas.

.....

..... [1]

(ii) Explain, in terms of kinetic particle theory, the relationship described in part **(a)(i)**.

.....

..... [1]

(b) Identify **one** difference between an "ideal gas" and a "real gas".

.....

..... [1]

(c) Some students analysed Fig. 8.1 and made these statements.

Jean: 'The stronger the intermolecular forces present in the real gas, the larger the difference between the volume of that real gas and an ideal gas at the same temperature.'

Beth: 'The extent that the volume of the real gas differs from an ideal gas depends on the number of covalent bonds present in each real gas molecule.'

Does the information in Fig. 8.1 support the statements made by Jean and Beth?

Based on your understanding of the structure and bonding present in chlorine gas, nitrogen gas and hydrogen gas, explain your reasoning.

.....

.....

.....

.....

.....

.....

..... [4]

(d) (i) A colourless gas, **R**, contains 52.2% carbon, 13.0% hydrogen and 34.8% oxygen by mass.

Deduce the **empirical formula** of gas **R**.
Show your working.

empirical formula = ... [3]

(ii) The molecular formula and empirical formula of gas **R** is the same.

Using Fig. 8.1, predict the volume of one mole of gas **R** at –200°C.

volume = ... dm^3 [1]

[Total : 11 m]

B9 Graphene and graphane are two modern materials that are being heavily researched on due to their useful properties.

Graphene is a two-dimensional layer of carbon atoms only (Fig. 9.1) while graphane is a two-dimensional layer of carbon and hydrogen atoms. Graphane has a similar structure to graphite, except that it has one hydrogen atom attached to each carbon atom as shown in Fig. 9.2.

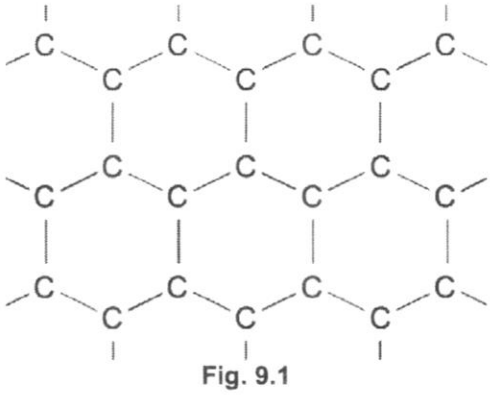


Fig. 9.1

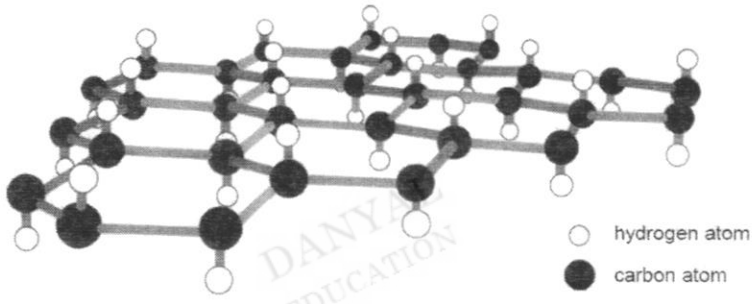


Fig. 9.2

(a) Explain, based on structure, why graphene is able to conduct electricity but graphane is unable to conduct electricity.

.....

.....

.....

.....

.....

..... [3]

(b) Both graphene and graphane are extremely strong and flexible material.

Explain, based on bonding, why both graphene and graphane are very strong materials.

.....

.....

.....

.....

..... [2]

(c) Scientists found that graphene is an excellent material for hydrogen storage. When graphene is reacted with hydrogen, it forms graphane.

$$2(\text{graphene}) + H_2 \rightarrow 2(\text{graphane})$$

Most hydrogen-powered cars carry 5000 g of hydrogen gas but in order to decrease the volume needed to store the hydrogen gas, hydrogen gas needs to be stored under extremely high pressures. Graphene and graphane allows for hydrogen gas to be stored under normal pressures.

(i) Calculate the volume occupied by 5000 g of hydrogen gas under room temperature and pressure.

volume = ... dm^3 [2]

(ii) Graphene has a very low density of 2267 g/dm^3.

Calculate the mass of graphene required to react with 5000 g of hydrogen gas and hence determine the volume of graphene required to react with 5000 g of hydrogen gas.
[1 mol of graphene is 12.0 g]

volume of graphene = ... dm^3 [2]

[Total : 9 m]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) number atomic symbol name relative atomic mass									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
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 –		

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 dm^3 at room temperature and pressure (r.t.p.).

2022 Sec 3 EOY Chemistry Examination

Paper 1

1	2	3	4	5	6	7	8	9	10
B	B	C	D	D	C	B	A	A	D
11	12	13	14	15	16	17	18	19	20
B	A	A	C	A	C	D	B	C	B
21	22	23	24	25	26	27	28	29	30
D	B	A	B	B	C	C	B	B	D
31	32	33	34	35	36	37	38	39	40
D	B	A	C	D	B	D	B	C	C

Paper 2

Section A (45 marks)

General Comments

Students perform well of questions that have been well rehearsed during lessons. Students will need to always furnish their answers with a greater level of specificity and details e.g. substances travel faster vs ions diffuse faster

Students will also need to be more flexible when it comes to questions that incorporate rmuliple topics and novel contexts. all calculations should be expressed in decimals and never in fractions

A1(a)	Isotopes are atoms having the same number of protons and different number of neutrons Commen mistakes involve students forgetting that isotopes can only be defined by comparing more than one atom and therefore atoms is an essential part of the definition accept: proton numbers,atomic number reject: an atom, amount of protons/neutrons (penalise only once), nucleon number, mass number.	All 3 – 2m Any 2 – 1m
(b)(i)	Carbon – 12 and carbon – 14	1
(ii)	Fluorine -19 and neon – 20 common error is to mention that magnesium-24 and carbon-12 have the same number of neutrons. it shows that it will be beneficial to always annotate questions with their thinking, instead of keeping it mentally in their minds	1

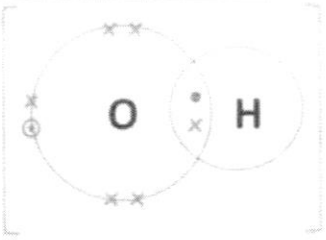
(iii) **(iv)**	Strontium – 90 and magnesium – 24 Iodine – 131 and fluorine-19 (iii) and (iv) are surprisingly poorly done by some students who lack a very fundamental understanding of ions and diatomic molecules.	4 pt - 2m, 3,2 pt - 1m, 1,0pt - 0m
		Total: 6m
A2(a)	Athlete 1 took ephedrine. Athlete 3 took ephedrine and insulin. Athlete 2 did not take drugs. Athlete 4 did not take drugs. Students who perform poorly in this question did not understand the command word as well as the requirement of this question. Many students were also not conscientious enough to describe for all athletes in the question.	All 4 - 2m 3,2 - 1m 0,1 - 0m
(b)	R_f ephedrine =1.9cm/4.8cm =0.40 (2 dp) R_f fifth athlete = 0.8cm/2.0cm =0.40 (2dp) He took ephedrine. Students either got the full 3 marks or left the question blank for this straightforward question. Students should also try to remember that Rf values are given to 2.d.p and that precision should be accounted in Science, i.e. a difference of 0.001 would not account for a significant difference. Students who did not prepare themselves with the appropriate stationery for an exam usually show incorrect ways of determining the Rf despite knowing the formula for calculating Rf value.	1 - for showing understanding of how to calculate Rf 1 - for showing accurate measurements with a ruler 1 - for showing calculations and a conclusion
		Total: 5m

A3(a)	The melting and boiling points in Group I <u>decrease down the group.</u> The melting and boiling points in Group VII <u>increase down the group.</u>	1 1
(b)(i)	B, A, C	1
(ii)	allow for ecf and B.O.D from (b)(i) A: Bromine, B: Iodine, C: Chlorine (any 3 halogen in the correct reactivity) This question was surprisingly badly done! Students were either not able to arrange elements in increasing order of reactivity or they did not know the relative reactivity of halogens. There were even some students who do not know what a "halogen" is.	1
(c)	Chlorine/ Fluorine (reject: chloride and fluoride) $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ OR $F_2 + 2KBr \rightarrow 2KCl + F_2$ Although this was explicitly taught and tested several times, some students were still unable to give proper chemical formulas for the halogens and their salts. Students are also reminded that they should refrain from giving state symbols when not required as incorrect state symbols e.g. Br_2 (g)/Br_2(s) will usually result in a deduction of marks. In this assessment, marks were not deducted.	1 1
		Total: 6m

A4(a)	• ammonium nitrate reacts with calcium hydroxide. • Calcium hydroxide will not be able to raise the pH of the soil / to neutralize acidic soil / adjust soil pH. • ammonia gas is released and • soil will not receive nitrogen content Although this was explicitly taught and tested many times in student tests and WAs, this question was surprisingly badly done. Students showed some worrying weaknesses. 1.Students were not specific enough to say that it was the removal of **calcium hydroxide** that resulted in the soil pH not being able to be adjusted and only made general statements. 2.Ammonium nitrate and calcium hydroxide will not give calcium nitrate and ammonium hydroxide. 3.Neutralisation reactions are restricted strictly for reaction of acids and alkalis to give salt and water. acid and carbonate, alkali and ammonium salt reactions are not neutralisation reactions.	4 pt - 2m 3,2 pt - 1m 1,0 pt - 0m
(b)(i)	$3Ca^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Ca_3(PO_4)_2(s)$ formula of calcium phosphate - 1pt all 3 state symbols – 1pt balanced equation - 1pt 1.We spent quite some time in Salt and QA discussing about precipitation reactions so students should have no issues knowing that precipitation involves the addition of two aqueous solutions (aq) to obtain a precipitate (s). 2.In chemical formula and chemical bonding, students should know how to derive a formula of an ionic compound with a cation with 2+ charge and a anion with 3- charge. 3.Several students did not balance the equation.	3pt - 2m 2,1 pt - 1m
(ii)	All **nitrate salts** are soluble and will not be able to form precipitates. accept: any salt that contains nitrate ions are soluble, reject: nitrate ions are soluble This question revealed a very glaring misconception in students understanding. Solubility is a property that is given to a **salt** and not an ion. If a free nitrate ion exist, it would definitely mean that it is dissolved in water and therefore the phrase "all nitrate ions are soluble" would be meaningless. Students should take care of their language in remembering solubility rules by saying that "all chloride salts are soluble except…" instead of saying "all chlorides are soluble except…" in order to ensure that such misconceptions do not arise again.	1
		Total: 5m

A5(a) **(i)**	$Cr_2O_7^{2-}$ Many students did not give the charge of the anion. STudents must always remember that ions are charged particles and therefore possess a charge.	1
(ii)	Since the molar mass of silver ion (108) is lesser than the molar mass of dichromate ion (216) And as silver ions diffuse faster Therefore both ions meet nearer to the ammonium dichromate to react to form the insoluble salt. accept: comparing silver nitrate and ammonium dichromate accept: getting the molar mass wrong but still stating that molar mass of the silver ion/silver nitrate is lesser than the dichromate ion/ammonium dichromate accept: molecular mass, relative molecular mass reject: mass of silver ion reject: travel/move (it is important for students to know how to use scientific words in their explanations) reject: anything about solubility	1 1
(iii)	Time taken will be shorter diffusion/movement is faster at higher temperatures. reject: dissolve faster/react faster 1.time cannot be faster, time moves at the same speed for everyone, my 24 h is moving at the same speed as your 24 h.	1
(b)	Filter the mixture and wash with distilled water and dry the residue Wrong method - max 1m Contradicting statements will also not be given any marks. Students will need to practise more careful and close reading of the question. Students only needed to describe how to remove an insoluble solid from a suspension (like obtaining sand from sea water) and ensure it is dry and pure. Some students describe a whole salt preparation process and this shows that they are merely memorising their work. Students who gave contradicting statements were not award the marks (e.g. filter the mixture and saturate the filtrate to obtain the salt)	1 1
		Total: 6m

A6(a)	Both reactions produce <u>bubbles</u>. acid reacts with metal	1
(i)	carbonates to produce <u>carbon dioxide</u>	1
	Most students miss out the bubbles and only state carbon	
(ii)	dioxide.	1
	Hydrochloric acid react faster/bubbles faster/bubbles more vigorously/ shorter time taken	1
	Ethanoic acid <u>ionises partially</u> to form lesser hydrogen ions whereas <u>hydrochloric acid</u> <u>completely ionises</u>.	
	Most students mention faster reaction but did not explain further on strong and weak acid.	2
(b)(i)	A – copper(II) oxide / CuO B – copper(II) chloride / $CuCl_2$	1
	Well - done	1
(ii)	ecf from part(i)	
	<u>Blue precipitate</u>	1
	<u>dissolves</u> to form a <u>dark blue solution</u>.	
	Students miss out dissolve or soluble in excess.	
(iii)	<u>salt formed is insoluble</u> and will <u>coat the metal oxide</u> <u>preventing further reaction</u> with the acid.	
	Some thought that lead or lead oxide is unreactive so no reaction.	
		Total: 9m
A7(a)	19.10 – 0.40	
	= <u>18.70 cm^3</u>	1
(b)	n(NaOH)	
	= 0.025 x 2	
	= <u>0.05 mol</u>	1
	n(H_2SO_4)	
	= 0.05 mol / 2	
	= 0.025 mol	
	c(H_2SO_4)	
	= 0.025 / 0.0187	
	= <u>1.34 mol/dm^3</u>	1
(c)	residual water will <u>dilute sulfuric acid in burette/decrease concentration</u>	1
	larger volume required for <u>same number of moles</u> for neutralization	1
	Most are able to state lower concentration but none is able to state the same number of moles reacted in larger volume.	

(d)(i)	 accept even if all electrons are same symbol Most are unable to draw correctly. Students either miss out electrons or charge or simply draw H_2O instead.	1

(d)(ii)	- solid state does not conduct - molten/aqueous state conduct electricity - solid state, ions are held in fixed positions/ in place, no mobile ions - molten/aqueous state, ions are mobile and move throughout liquid 4pt – 2m, 3-2 pt – 1m, 1-0pt – 0m Most students only mention no mobile ions in solid state instead of ions in fixed positions. They also used mobile electrons instead of ions.	2
		Total: 8m

Section B (20 marks)

B8(a)(i)	As temperature increases, the molar volume increases Well done. A small number of students did not use the term 'molar' and this was not penalize for this paper only	1
(ii)	As temperature increases, particles gain more energy and move further apart (reject: gas expands (macroscopic observation)) Many students did not mention that the particles move **further apart**, instead they describe the intensity of the movement. They were many attempts to use other terms to describe **further apart** which was accepted e.g spaces increase, the space further. Students are advise to avoid such terms as they could be penalize.	1

(b)	Real gases have intermolecular forces between molecules while ideal gases have no intermolecular forces. **OR** Volume of real gases is smaller than ideal gases at the same temperature. Most did not use the term **at the same temperature**. This was not penalize for this paper only. There were several confusing answers that discuss the type of particles present in real and ideal gases or the trends of the graphs.	1
(c)	Agree with Jean. Disagree with Beth. Chlorine gas the strongest intermolecular force as it has the highest molecular mass (71) as compared to nitrogen (28) and hydrogen (2). Nitrogen has the greatest number of covalent bonds / more covalent bonds than hydrogen and chlorine however the difference from an ideal gas is the greatest for chlorine instead **OR** Hydrogen and chlorine has one covalent bond / single bond / same number of covalent bonds however the difference from an ideal gas is not the same or greatest for chlorine (reject if student gets molecule/atom/ion mixed up) Poorly done. Common misconception 1. Strength of intermolecular attraction of gas molecules are due to the charge of the ions / the distance of the valence electrons from the nucleus 2. The number of bonds is related to the number of valence electrons 3. Chlorine forms 2 covalent bonds There were also several students who rewrote Jean and Beth's statements without any supporting evidence. They were also several confusing interpretations of the question that was difficult to understand the thought process behind their answers.	1 1 1 1 Total 4

(d)(i)

	C	H	O	
%	52.2	13.0	34.8	
Ar	12	1	16	
	$(A)\frac{52.2}{12} = 4.35$	$(B)\frac{13.0}{1} = 13.0$	$(C)\frac{34.8}{16} = 2.175$	
	$\frac{4.35}{2.175} = 2$	$\frac{13.0}{2.175} = 5.98$	$\frac{2.175}{2.175} = 1$	
Ratio	2	6	1	

(A), (B), (C) – Any 2 for 2m — 2

C_2H_6O — 1

Well done by several students.
Those who did poorly mostly either
1. Divide atomic mass by percentage
2. Use H_2 and O_2

(ii) between 4.8 dm^3 and 5.8 dm^3 — 1
ECF from (d)(i)

Total: **11m**

B9(a) Each of the carbon atoms in graphene uses 3 of its 4 valence / outer electrons to form covalent bonds and — 1
hence — 1
there is one mobile electron that can move to conduct electricity. — 1
In graphane all of its valence / outer electrons is involved in covalent bonding.

Poorly done.
Students did not use the term **valence/outer** electron. If the students use the term **valence/outer** electrons correctly once they will be given credit if they miss the terms at the other parts of their answers.

Wrong concept:
They were many students who wrote 'one carbon atom not used in bonding' to explain the conductivity.

No credit given:
Students who discuss the number of bonding the carbon atoms formed without using the term **valence/outer** electron.
Students who use the term **delocalise** electron instead of **mobile** electron.

A few students did not attempt the question.

(b)	All the atoms are held by <u>strong covalent bonds</u> that requires <u>a lot of energy to overcome.</u> Well done. They were several students who use the term **intermolecular attraction** to explain the strength, no credit was given. Accept when students use both **intermolecular attraction** and **covalent bonds** to explain the strength.	1 1
(c)(i)	$n(H_2)$ =5000/2 <u>=2500 mol</u> $v(H_2)$ =2500 x 24 <u>= 60 000 dm^3</u> Poorly done, with many students who use the mass of one H atom. No ECF was awarded within the question.	 1 1
(ii)	n(graphene) = 2500 x 2 = 5000 mol mass(graphene) = 5000 x 12 <u>= 60 000 g</u> volume(graphene) =60000 / 2267 <u>=26 dm^3</u> Poorly done. Students were very confused with the density given and attempted several calculations that does not make any sense. They were also several attempts to assume graphene is a gas. Several students did not attempt the question.	 1 1
		Total: 9m