Surname:	**First Name:**

Current School:

Shrewsbury School

SHREWSBURY SCHOOL

SIXTH FORM ENTRANCE EXAMINATION 2025 ENTRY

CHEMISTRY
(1 Hour)

Instructions to candidates:

- Answer **ALL THIRTY** questions from **SECTION A** on the grid provided **and**
- Answer **TWO** of the **THREE** questions from **SECTION B** in the spaces provided

Section A is worth **30 marks** and **Section B 20 marks**. 50 marks in total.

You may use a calculator.

You are provided with a **copy of the Periodic table**

The Periodic Table of the Elements

Group																
I	II										III	IV	V	VI	VII	0
							1 H Hydrogen 1									4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulphur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86
Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89														

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

*58-71 Lanthanoid series
90-103 Actinoid series

Key

a
X
b

a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

Answer **ALL** questions from **SECTION A** on the grid provided**.**

SECTION A

Answer all questions – circle the correct letter for each question below.

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D
11	A	B	C	D
12	A	B	C	D
13	A	B	C	D
14	A	B	C	D
15	A	B	C	D
16	A	B	C	D
17	A	B	C	D
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D
21	A	B	C	D
22	A	B	C	D
23	A	B	C	D
24	A	B	C	D
25	A	B	C	D
26	A	B	C	D
27	A	B	C	D
28	A	B	C	D
29	A	B	C	D
30	A	B	C	D

Question 1

The Group I element potassium forms an ionic bond with the Group VII element fluorine.

Which two ions are produced?

A K^+ and F^+ **B** K^+ and F^- **C** K^- and F^- **D** K^- and F^+

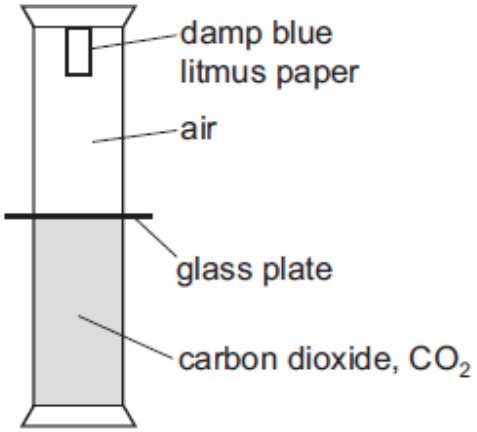
Question 2

Four experiments, each containing a different acidic gas, are set up as shown.

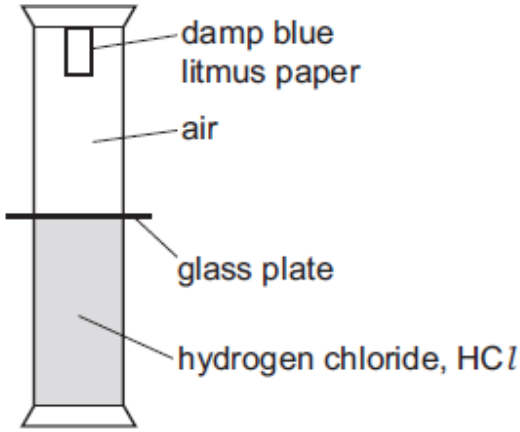
The dividing glass plates are removed at the same time.

In which set of apparatus does the litmus turn red first?

A



B



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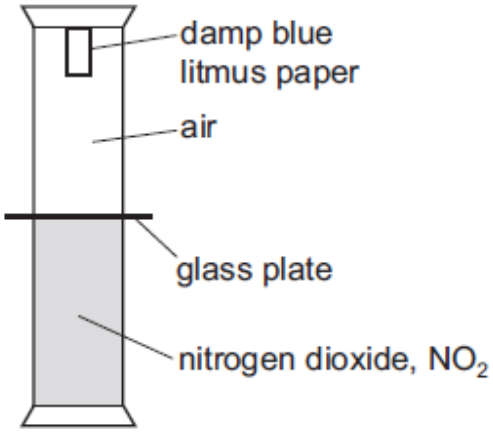

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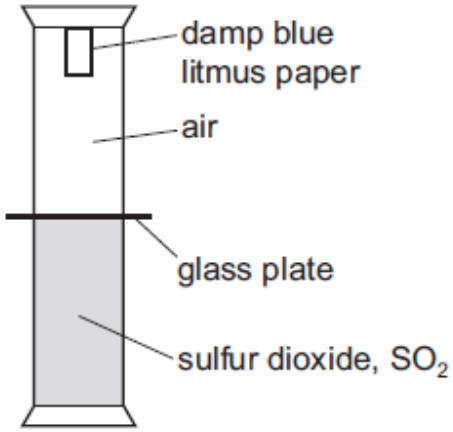


Question 3

X and Y are atoms.

- X and Y have the same number of electron shells.
- X and Y have the same number of outer electrons.
- X and Y have different mass numbers.

Which statements about X and Y are correct?

1 X and Y are isotopes.

2 X and Y have the same total number of electrons.

3 X and Y have the same chemical properties.

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

Question 4

Lithium chloride is an ionic compound and silicon(IV) oxide is a covalent compound.

Which statement about **both** compounds is correct?

A They are not soluble in water.

B They conduct electricity when melted.

C They do not conduct electricity in solid form.

D They have low melting points.

Question 5

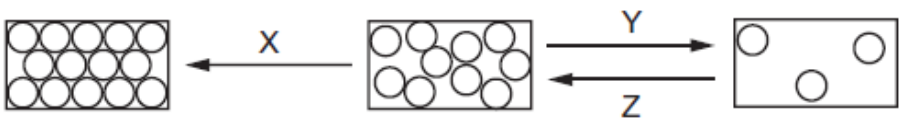
Which row shows the formulae of sodium carbonate, zinc nitrate and ammonium sulfate?

	sodium carbonate	zinc nitrate	ammonium sulfate
A	Na_2CO_3	$ZnNO_3$	$(NH_4)_2SO_4$
B	Na_2CO_3	$Zn(NO_3)_2$	$(NH_4)_2SO_4$
C	$NaCO_3$	$ZnNO_3$	$(NH_3)_2SO_4$
D	$NaCO_3$	$Zn(NO_3)_2$	$(NH_3)_2SO_4$

Question 6

The three rectangles show the arrangements of the particles in each of the three states of matter.

X, Y and Z represent the processes needed to change from one state to another.



What are the processes X, Y and Z?

	X	Y	Z
A	melting	condensing	evaporating
B	evaporating	melting	freezing
C	melting	freezing	condensing
D	freezing	evaporating	condensing

Question 7

The equation for the combustion of methane is shown.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Which mass of methane produces 36 g of water?

A 16 g **B** 18 g **C** 32 g **D** 64 g

Question 8

Graphite has a giant covalent structure.

Which statements about graphite are correct?

1 Carbon atoms form four covalent bonds with neighbouring atoms.

2 There are delocalised electrons between layers of carbon atoms.

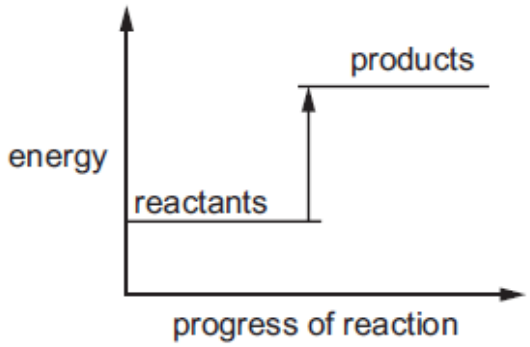
3 Graphite is a useful lubricant.

4 Graphite is a good conductor of electricity.

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

Question 9

The reaction pathway diagram for a reaction is shown.



Which statements are correct?

1 The reaction is exothermic.

2 The reaction is endothermic.

3 The temperature of the surroundings increases.

4 The temperature of the surroundings decreases.

A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

Question 10

Which solids react with dilute sulfuric acid to form aqueous magnesium sulfate?

1 magnesium

2 magnesium hydroxide

3 magnesium nitrate

4 magnesium oxide

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

Question 11

The formula of a compound containing element X is $Na_2X_2O_3$.

The relative formula mass of the compound is 158.

What is the relative atomic mass of X?

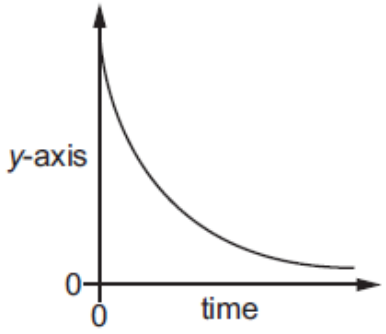
A 32 **B** 59.5 **C** 64 **D** 119

Question 12

An experiment is carried out to find the rate of reaction between hydrochloric acid and zinc.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

The results of the experiment are shown.



What is the label on the *y*-axis?

A amount of $ZnCl_2$ produced

B concentration of HCl

C mass of Zn reacted

D volume of H_2 produced

Question 13

Lithium, sodium and potassium are elements in Group I.

Statements about these elements are listed.

1 Lithium is more dense than sodium.

2 Sodium is more reactive than potassium.

3 They all conduct electricity at room temperature.

4 They all react with oxygen at room temperature.

Which statements are correct?

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

Question 14

Copper(II) sulfate is formed by reacting excess solid copper(II) carbonate with dilute sulfuric acid.

Which processes are part of the preparation of solid copper(II) sulfate?

1 crystallisation

2 distillation

3 filtration

4 titration

A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

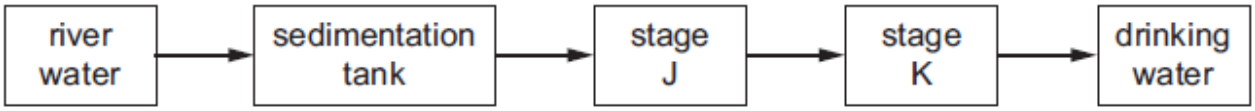
Question 15

Which row compares the strength of alloys with pure metals and explains the difference in strength?

	strength of an alloy compared to a pure metal	explanation
A	weaker	larger atoms slide more easily over smaller atoms
B	weaker	larger atoms make it harder for layers to slide over one another
C	stronger	larger atoms slide more easily over smaller atoms
D	stronger	larger atoms make it harder for layers to slide over one another

Question 16

The flow chart shows stages in the treatment of river water to produce drinking water.



What occurs at stages J and K?

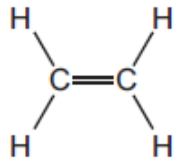
	J	K
A	distillation	chlorination
B	distillation	filtration
C	filtration	chlorination
D	filtration	distillation

Question 17

Ethene can be polymerised.

Which diagram represents the structure of the product formed?

A



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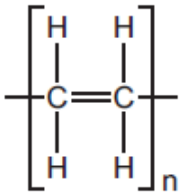

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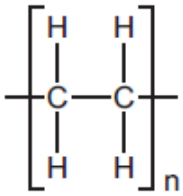

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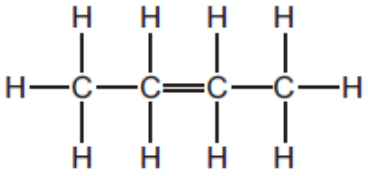
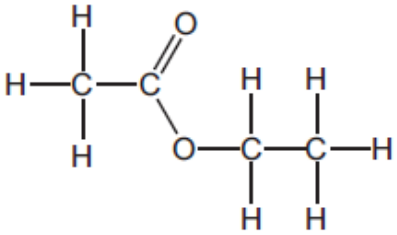


Question 18

The diagram shows the structure of a molecule of ethyl ethanoate.



What is the molecular formula of a molecule of ethyl ethanoate?

A CHO **B** $C_4H_8O_2$ **C** $C_4(H_2)_2(O_2)$ **D** C_2H_4O

Question 19

A hydrocarbon contains 85.7% of carbon by mass.

What is the empirical formula of the hydrocarbon?

A CH_2 **B** CH_4 **C** C_2H_5 **D** C_3H_6

Question 20

The initial and final temperatures of four different reactions are measured.

Which reaction is the **least** exothermic?

	initial temperature / °C	final temperature / °C
A	19	25
B	21	18
C	22	17
D	22	26

Question 21

An acid–base titration is described.

- 25.0 cm^3 of dilute aqueous alkali is put into a conical flask.
- Indicator is added to the flask.
- Dilute acid is added to the aqueous alkali until the indicator changes colour.
- The volume of acid used is then recorded.

Which use of apparatus is correct?

A The 25.0 cm^3 of aqueous alkali is measured using a volumetric pipette.

B The 25.0 cm^3 of aqueous alkali is measured using the lines on the conical flask.

C The volume of acid is measured using a measuring cylinder.

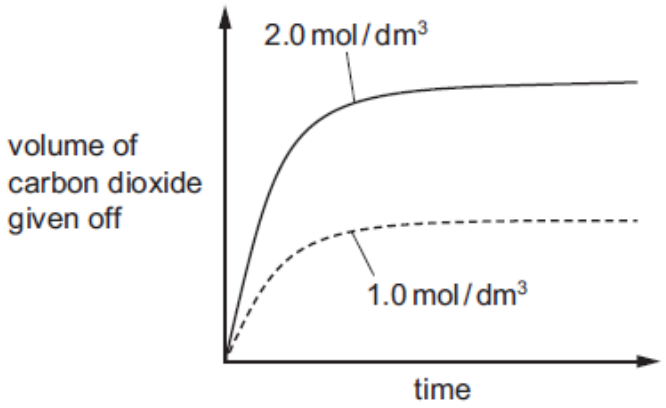
D The volume of acid is measured using a volumetric pipette.

Question 22

Hydrochloric acid is added to excess calcium carbonate in two separate experiments.

Two different concentrations of hydrochloric acid are used but the temperature is the same in both experiments.

The graph of the results shows the volume of carbon dioxide gas given off over time.



Which row is correct?

	particles in 2.0 mol / dm^3 compared to 1.0 mol / dm^3	
	collision rate	collision energy
A	higher	no change
B	higher	higher
C	lower	no change
D	lower	higher

Question 23

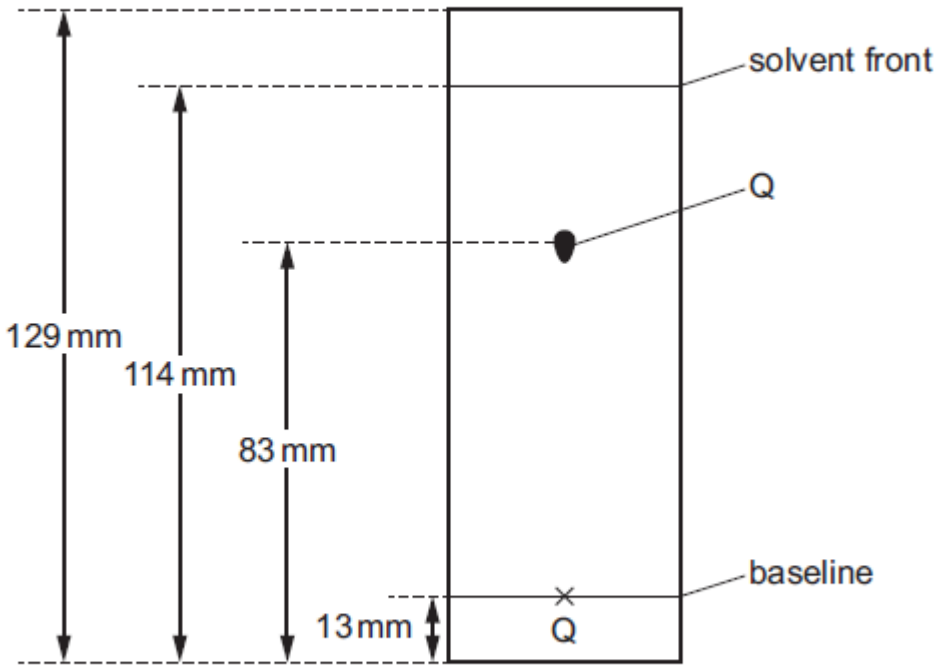
What is the total number of covalent bonds in a molecule of butane, C_4H_{10}?

A 3 **B** 10 **C** 13 **D** 14

Question 24

Substance Q is investigated using chromatography.

The chromatogram is shown. The diagram is not drawn to scale.



What is the R_f value of Q?

A 0.60 **B** 0.64 **C** 0.69 **D** 0.72

Question 25

Which test is used to show that a sample of water is pure?

A Evaporate the water to see if any solids remain.

B Heat the water to check its boiling point.

C Test with anhydrous cobalt(II) chloride.

D Use universal indicator paper to check its pH.

Question 26

Petroleum is separated into fractions by fractional distillation.

Which row describes a use of the named fraction?

	fraction	use
A	bitumen	fuel for ships
B	refinery gas	jet fuel
C	fuel oil	road making
D	gasoline	fuel for cars

Question 27

Ethane is used as a fuel.

Which equation shows the complete combustion of ethane?

A $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

B $2C_2H_6 + 5O_2 \rightarrow 4CO + 6H_2O$

C $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

D $C_2H_4 + 2O_2 \rightarrow 2CO + 2H_2O$

Question 28

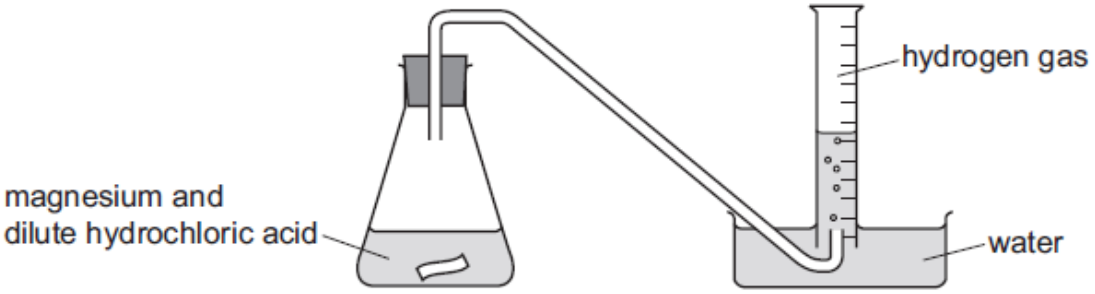
The table shows some physical properties of four different substances.

Which row describes the properties of a non-metallic element?

	melting point /°C	conductivity when solid	conductivity when melted
A	63	good	good
B	119	poor	poor
C	659	good	good
D	808	poor	good

Question 29

The apparatus used to investigate the rate at which hydrogen gas is given off when a piece of magnesium reacts with dilute hydrochloric acid is shown.



Which additional piece of apparatus is needed to determine the rate of reaction?

A balance

B burette

C stop-watch

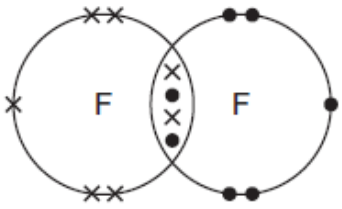
D volumetric pipette

Question 30

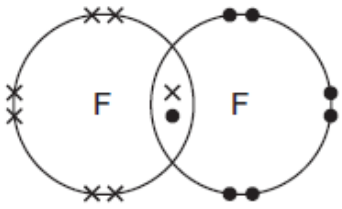
Fluorine, F_2, is in the same group of the Periodic Table as chlorine, Cl_2.

Which diagram represents the arrangement of the outer-shell electrons in a molecule of fluorine?

A



B



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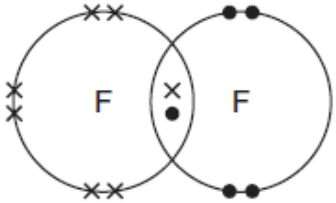

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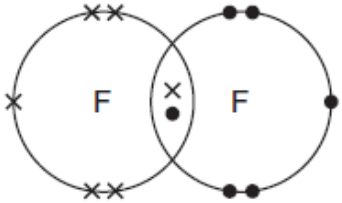

END OF SECTION A

Section B [Answer **TWO** of the **THREE** questions]

Question 1

Cobalt and copper are transition elements.

(a) Copper has two naturally occurring isotopes, ^{63}Cu and ^{65}Cu. Cobalt has only one naturally occurring isotope, ^{59}Co.

(i) Complete Table 2.1 to show the number of protons, neutrons and electrons in the ^{59}Co atom and the $^{65}Cu^{2+}$ ion.

Table 2.1

	^{59}Co	$^{65}Cu^{2+}$
protons		
neutrons		
electrons		

[3]

(ii) Table 2.2 shows the relative abundance of the two naturally occurring isotopes of copper.

Table 2.2

isotope	^{63}Cu	^{65}Cu
relative abundance	70%	30%

Calculate the relative atomic mass of copper to **one** decimal place.

relative atomic mass = ... [2]

(b) Both copper and cobalt can form coloured compounds. Some of these compounds contain water of crystallisation.

(i) State the colour change seen when a few drops of water are added to anhydrous copper(II) sulfate.

from ..... to ..... [1]

(ii) State how this colour change can be reversed.

..... [1]

(c) This question is about lead(II) chloride, $PbCl_2$.

A student prepares a sample of insoluble lead(II) chloride, $PbCl_2$, by mixing aqueous solutions of **two** salts in a beaker.

(i) Identify **two** soluble salts suitable for making lead(II) chloride when mixed together.

.....

..... [2]

(ii) Write the ionic equation for the formation of lead(II) chloride by mixing aqueous solutions.

..... [1]

[Total: 10]

Question 2

Aqueous hydrogen peroxide, H_2O_2, slowly forms water and oxygen at room temperature and pressure, r.t.p. This reaction is catalysed by manganese(IV) oxide.

The equation is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

(a) State the test for oxygen gas.

test .....

observations .....

[1]

(b) A student investigates the rate of formation of oxygen gas when manganese(IV) oxide is added to aqueous hydrogen peroxide.

The volume of oxygen gas formed is measured at regular time intervals at r.t.p. The results are plotted onto the graph in Fig. 4.1.

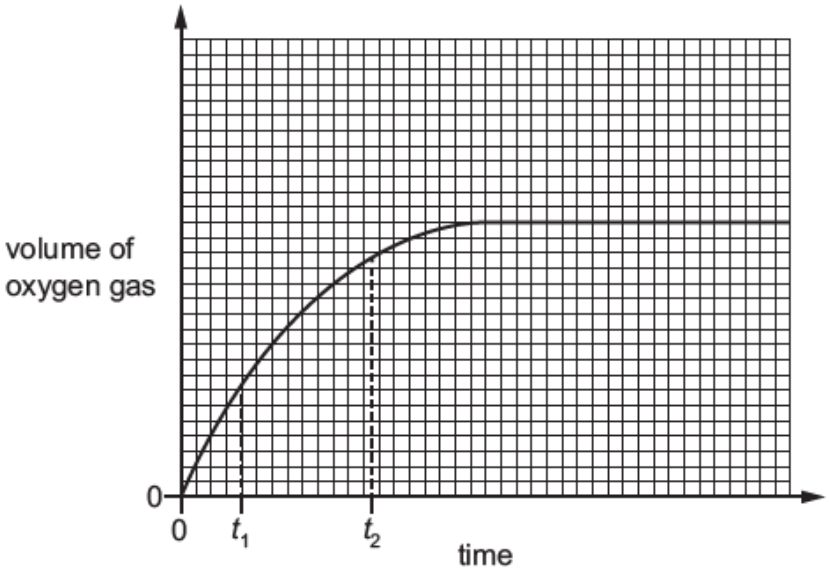

Fig. 4.1

(i) State how the graph in Fig. 4.1 shows the rate of reaction at time t_2, is lower than at time t_1.

..... [1]

(ii) Explain, using collision theory, why the rate of reaction at time t_2 is lower than at time t_1.

.....

.....

..... [2]

(iii) On Fig. 4.1, sketch the graph obtained when the experiment is repeated using aqueous hydrogen peroxide at a higher temperature. All other conditions remain the same. [1]

(c) Aluminium reacts with fluorine to form aluminium fluoride, AlF_3, an ionic compound.

(i) Write the symbol equation for this reaction.

..... [2]

(ii) Complete Fig. 2.2 to show the electronic configuration of one aluminium ion and one fluoride ion.
Show the charges on the ions.

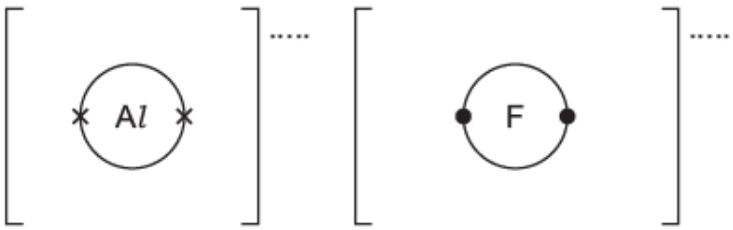

Fig. 2.2

[3]

[Total: 10]

Question 3

(a) The equation for the reaction between tetrachloromethane gas and steam can be represented as shown in Fig. 5.2.

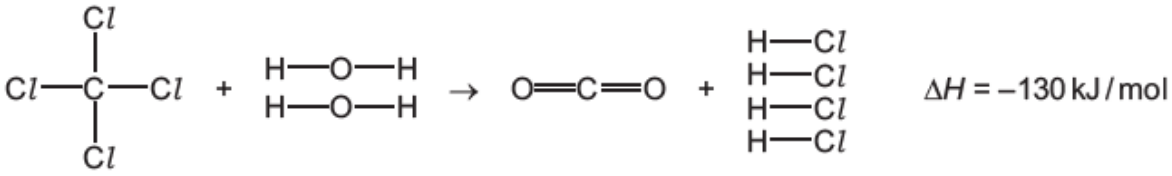

Fig. 5.2

Table 5.1 shows some bond energies.

Table 5.1

bond	C–C*l*	H–O	C=O
bond energy in kJ / mol	340	460	805

Use the bond energies in Table 5.1 and the ΔH value for the reaction to calculate the H–C*l* bond energy using the following steps.

- Calculate the energy needed to break the bonds in the reactants.

..... kJ

- Calculate the energy released when the bonds in carbon dioxide form.

..... kJ

- Calculate the H–C*l* bond energy.

..... kJ / mol
[4]

(b) The solubility of solid sodium sulfate in water changes as the temperature of the water changes.

Plan an experiment to find out how the solubility of sodium sulfate in water changes with temperature.

You are provided with sodium sulfate, distilled water and common laboratory apparatus.

.... [6]

[Total: 10]