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16+ PAST PAPER PACK

Rugby School 16+ Chemistry 2020

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CONTENTS

Name: _____ School: _____

Rugby School

Sixth Form Entrance Examination

November 2020

Chemistry

Time allowed: 1 hour

This paper is divided into two sections, both of which must be attempted.
You **must** write your name on the front of this booklet.

Section A: multiple choice (30 marks)
Section B: short answer questions (30 marks)

A Data Sheet and a Periodic Table are provided (inside front cover and first page)

Equipment Required: Pen, pencil, ruler and calculator

For examiner's use only:

Section A	/30
Section B	/30
Total	/ 60

THE PERIODIC TABLE

Period	Group 1	2											3	4	5	6	7	0
1							1 H Hydrogen 1											4 He Helium 2
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
3	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
4	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	63.5 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
5	86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 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
6	133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 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	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
7	223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key

Relative atomic mass
Symbol
Name
Atomic number

Chemistry Data Sheet

1. Reactivity Series of Metals

Potassium	most reactive
Sodium	
Calcium	
Magnesium	
Aluminium	
Carbon	
Zinc	
Iron	
Tin	
Lead	
Hydrogen	
Copper	
Silver	
Gold	
Platinum	least reactive

(elements in italics, though non-metals, have been included for comparison)

2. Formulae of Some Common Ions

Positive ions		Negative ions	
Name	Formula	Name	Formula
Hydrogen	H^+	Chloride	Cl^-
Sodium	Na^+	Bromide	Br^-
Silver	Ag^+	Fluoride	F^-
Potassium	K^+	Iodide	I^-
Lithium	Li^+	Hydroxide	OH^-
Ammonium	NH_4^+	Nitrate	NO_3^-
Barium	Ba^{2+}	Oxide	O^{2-}
Calcium	Ca^{2+}	Sulfide	S^{2-}
Copper(II)	Cu^{2+}	Sulfate	SO_4^{2-}
Magnesium	Mg^{2+}	Carbonate	CO_3^{2-}
Zinc	Zn^{2+}		
Lead	Pb^{2+}		
Iron(II)	Fe^{2+}		
Iron(III)	Fe^{3+}		
Aluminium	Al^{3+}		

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Section A

You should complete this section using the answer grid provided.

1 Below are some statements regarding the smokeless fuels *Burnbrite* and *Hiheat*. Which of these statements **cannot** be checked scientifically?

A *Burnbrite* produces less ash than *Hiheat*
B *Hiheat* is a better solid fuel than *Burnbrite*
C 1 kg of *Burnbrite* produces more heat when it is burned than 1 kg of *Hiheat*
D *Burnbrite* produces more sulfur dioxide than *Hiheat*

2 When a geologist tested a sample of copper ore with dilute hydrochloric acid, a gas was given off. This suggests the ore could contain…

A $CuCO_3$
B $CuCl_2$
C $CuSO_4$
D $Cu(OH)_2$

3 A metal atom X has the electron arrangement 2,8,3 and a non-metal atom Y has the electron arrangement 2,8,6. What is the correct formula for the compound formed between elements X and Y?

A X_2Y
B XY
C XY_2
D X_2Y_3

4 Hydrochloric acid reacts with iron (II) sulfide to produce hydrogen sulfide gas. Under which of the following sets of conditions would the reaction start at the **slowest** rate?

	Concentration of acid (mol/dm^3)	Temperature (^oC)	State of iron (II) sulfide
A	1.0	15	Powdered
B	0.1	30	Powdered
C	0.1	15	Lumps
D	2.0	30	Lumps

5 What group number of the periodic table are the Alkaline Earth Metals in?

A 2
B 0
C 1
D 7

6 Which of the following is the correct formula for niobium (V) oxide

A Nb_5O
B NbO_5
C Nb_5O_2
D Nb_2O_5

7 Many chemical reactions produce energy because…

A the reactants must be heated for the reaction to begin
B bonds have broken during the reaction
C the products have weaker bonds than the reactants
D the energy content of the products is less than that of the reactants

8 Magnesium is more reactive than zinc. This means that…

A zinc will displace magnesium from a solution of magnesium sulfate
B zinc will corrode in preference to magnesium
C magnesium displaces chlorine from potassium chloride (aq), but zinc will not
D magnesium forms ions more readily than zinc

9 Which one of the following contains the greatest percentage by mass of potassium?

(relative atomic masses: H = 1, C = 12, O = 16, K = 39)

A KOH
B $KHCO_3$
C K_2CO_3
D $K_2C_2O_4$

10 This question refers to the two particles **X** and **Y**. The table shows some data for X and Y.

	Particle **X**	Particle **Y**
Number of protons	26	26
Number of neutrons	30	31
Number of electrons	24	23

Particles **X** and **Y** are…

A atoms of the same element
B atoms of different elements
C ions of the same element
D ions of different elements

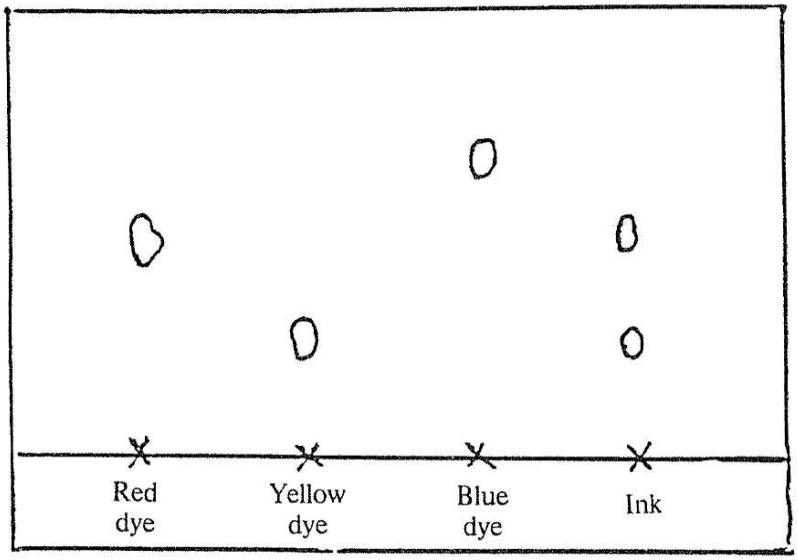
11 Sodium chloride is…

A an element
B a molecule
C a compound of two non-metals
D a compound of a metal and a non-metal

12 Which of the following gases is not considered to be a cause of air pollution?

A sulfur dioxide
B nitrogen dioxide
C carbon monoxide
D carbon dioxide

13 The diagram of a chromatogram shows the dyes present in an ink. Spots of red, yellow and blue dyes were used as well as the ink.



The ink contained…

A blue and yellow dyes.
B red dye only.
C red and yellow dyes.
D yellow, red and blue dyes.

14 Indigestion is caused by the presence of an excess of acid in the stomach. Which of the following substances could an indigestion tablet contain to neutralise this acid?

A magnesium hydroxide
B sugar
C sodium chloride
D lemon juice

15 Which of the following is a single compound?

A air
B seawater
C limestone
D chocolate

16 The table below shows the melting points of the elements in Group 1. The melting point of rubidium is missing.

Element	Li	Na	K	Rb	Cs
Melting Point (°C)	180	98	64		29

The most likely melting point of rubidium is…

A 31 °C
B 55 °C
C 39 °C
D 115 °C

17 Newly laid bricks sometimes become coated with an alkaline white deposit. The best way to remove this deposit is to wash it with a mixture of detergent and a chemical that will react with the white deposit.

Which one of the following could be used with the detergent in the mixture?

A vinegar
B limewater
C sodium hydroxide solution
D ethanol

18 Methanoic acid (a weak acid) is present in many kettle/steam iron descalers. What pH would you expect a solution of methanoic acid to have?

A 1
B 13
C 7
D 5

19 Pollution of the environment is reduced by…

A burning coal in power stations
B adding fertilisers to the soil
C replacing metal items with plastic items
D using a catalytic converter on a car exhaust

20 Which change of state occurs when dry ice (solid carbon dioxide) is heated and converted into a gas for stage effects?

A condensation
B sublimation
C evaporation
D solidification

21 Which of the following compounds contains the largest number of atoms?

A	aluminium oxide	Al_2O_3
B	ammonium sulfate	$(NH_4)_2SO_4$
C	calcium nitrate	$Ca(NO_3)_2$
D	hydrated copper(II) sulfate crystals	$CuSO_4.5H_2O$

22 The metal most commonly used for a drink can is…

A aluminium
B iron
C tin
D copper

23 Carbon dioxide is a gas which…

A is insoluble in water
B makes up 0.93% of earth's atmosphere
C burns in air
D is more dense than air

24 2.0 g of magnesium metal were reacted with an excess of dilute sulphuric acid. The volume of gas given off was measured at one minute intervals. The results of this experiment are shown in the table below:

Time (min)	0	1	2	3	4	5	6	7	8	9	10
Volume (cm^3)	0	16	25	35	40	44	47	49	50	50	50

The time needed for 1.0 g of magnesium to react was

A 1 minutes
B 2 minutes
C 4 minutes
D 8 minutes

25 A sample of sodium chloride has become contaminated with dust. What sequence of operations is the best way to obtain pure sodium chloride?

A solution, crystallisation, filtration
B decantation, solution, precipitation
C solution, filtration, crystallisation
D solution, filtration, evaporation

Questions 26 – 30, choose from the list A to D

A Water (H_2O)
B Hydrogen chloride (HCl)
C Sodium chloride (NaCl)
D Diamond (C)

26 The substance that has a giant covalent structure

27 The substance that consists of ions in a giant structure

28 The substance which boils at -85 ^0C

29 The substance that forms dense white fumes with ammonia gas

30 The substance that contains no covalent bonds

Total marks (30)

[END OF SECTION A]

Section B

1 Complete the following table for the atoms shown

Element	Symbol	Atomic Number	Mass Number	Protons	Neutrons	Electrons
Sodium			23			
		13	27			
				9	10	
	K		39			

(2)

2 Copy and complete the following table for the ions shown

Ion	Symbol	Atomic Number	Mass Number	Protons	Neutrons	Electrons
				3	4	2
	O^{2-}		16			
Magnesium		12				
		15	31			18

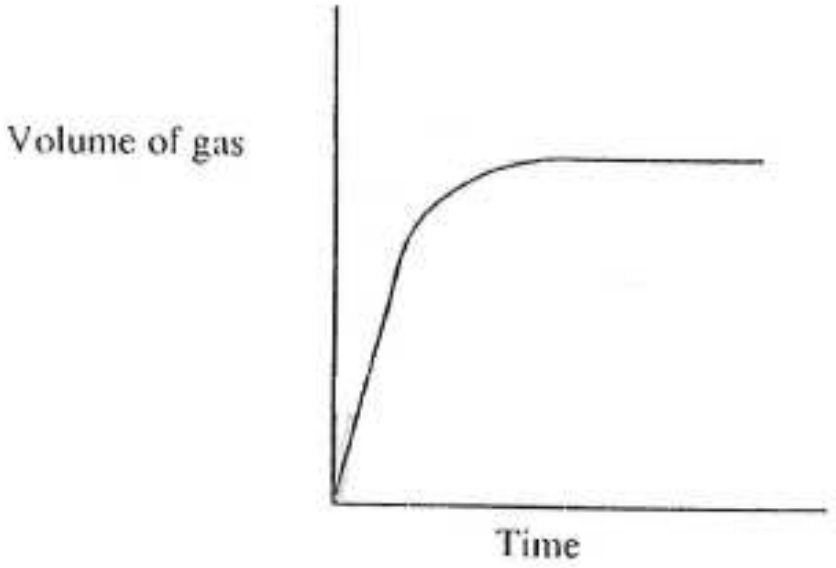
(2)

3 A company which produces sweets was introducing a new product called "Moon Dust". This sweet was in the form of a powder, which fizzed in water. The fizziness was investigated before it was put on the market.

Three different experiments were carried out.

Experiment	Mass of powder added to 1 litre of water	Temperature (°C)
1	40	25
2	40	37
3	20	25

For each experiment, a graph was plotted of the volume of gas produced against time. The graph for experiment 1 is shown below.



On the graph above, sketch the plots for experiments 2 and 3 on to it. Label each curve clearly.

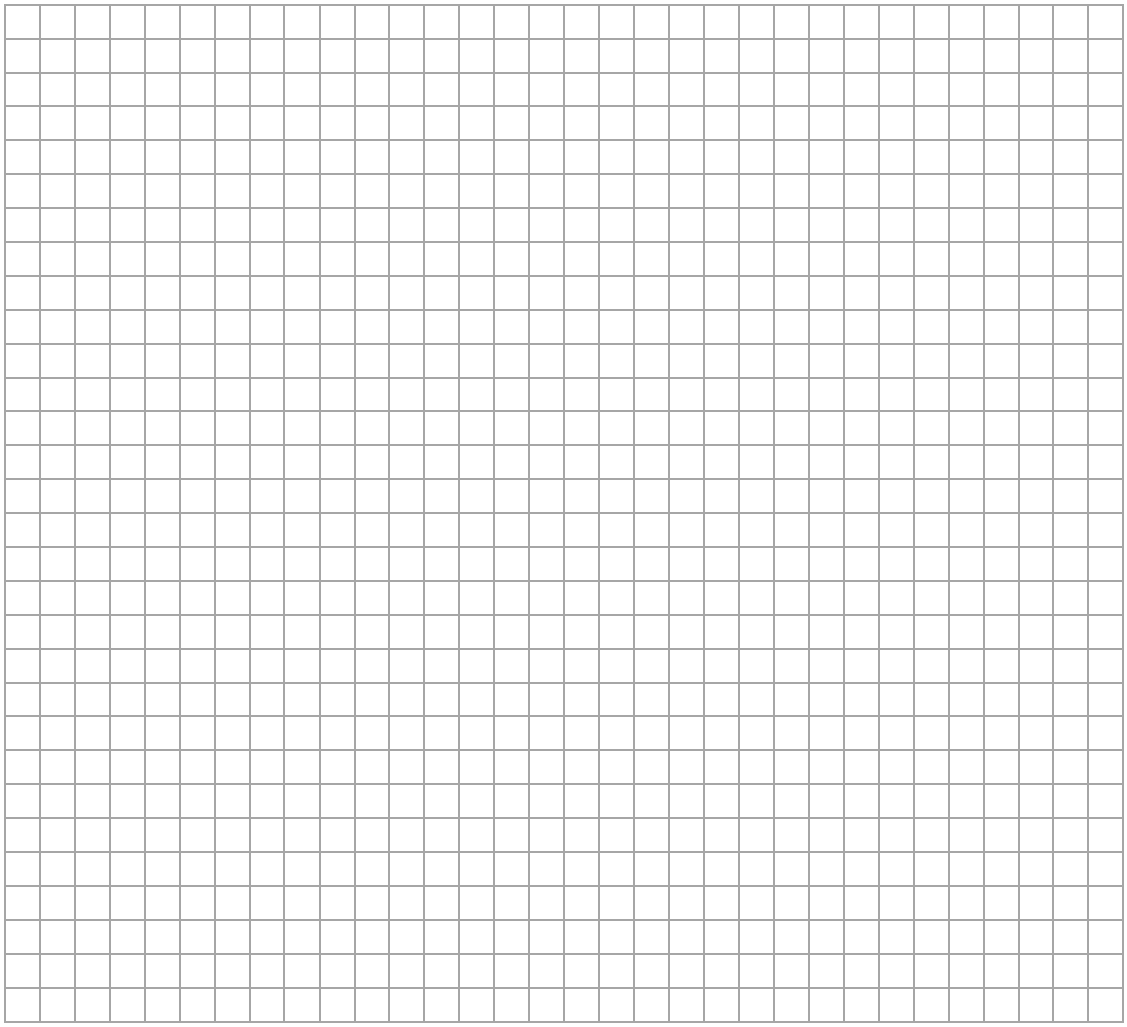
(2)

4 In 1926 the plastic *Polysynth* was invented and immediately used in household furniture. The material was found to generate poisonous fumes when burnt. The fire services kept the following statistics.

Year	*Polysynth* used in household furniture (tons)	Household fire deaths
1910	0	10
1920	0	10
1930	1000	12
1940	4000	18
1950	7000	24
1960	10000	30
1970	10000	30
1980	0	10

a) Use the graph paper below to plot a bar chart of household deaths against year.

The grid below is 32 squares wide and 30 squares high. Spare graph paper is provided on the back page.



(3)

b) Describe the relationship between the quantity of plastic used and the number of household fire deaths from fumes?

(1)

c) What evidence is there in the statistics that not all fire deaths were due to *Polysynth*?

(1)

5 The corrosion of iron was investigated by giving six identical iron nails different treatments. A seventh nail was left untreated. All seven nails were then left exposed to the atmosphere for several days.

The results of the experiment are given below.

Nail	Treatment	Cost of treatment	Initial mass of nail (g)	Final mass of nail (g)
A	waxed	low	5.0	5.3
B	oiled	low	5.0	4.1
C	chromium plated	high	5.0	5.0
D	painted	low	5.0	5.4
E	galvanised	high	5.0	5.1
F	salted	low	5.0	6.7
G	untreated	nil	5.0	6.1

a) What happens to the mass of a nail when it corrodes?

(1)

b) Which nail was weighed incorrectly after exposure to the atmosphere?

(1)

c) Which nail was best protected against corrosion?

(1)

d) Which nail received a treatment which made corrosion much worse?

(1)

6 **a)** Complete the following table. Use the words *solid*, *liquid* or *gas*.

Element	Melting point (°C)	Boiling point (°C)	Physical State at 25 ^{0}C
Iron	1535	2750	
Fluorine	-220	-188	
Mercury	-39	357	
Iodine	114	184	
Nitrogen	-210	-196	
Sodium	98	883	
Bromine	-7	59	
Xenon	-112	-107	

(2)

c) What is the name given to the elements in group 1?

(1)

d) What is the name given to the elements in group 7?

(1)

e) Explain why elements in the same group exhibit similar chemical properties.

(1)

7 Complete the following table. Use the words *metallic*, *ionic* or *covalent*.

Substance	Melting point (°C)	Boiling point (°C)	Type of bonding
Nitrogen	-210	-196	
Sodium	98	883	
Sulfur dioxide	-73	-10	
Water	0	100	
Ethane	-183	-88	
Magnesium chloride	712	1418	

(3)

8 Using the table below to answer the following questions.

Ionic Compound	Colour
Potassium chromate	Yellow
Sodium chloride	White
Nickel (II) sulfate	Green
Sodium chromate	Yellow
Copper (II) chloride	Blue
Potassium chloride	White
Potassium permanganate	Purple
Nickel (II) chloride	Green

a) Deduce the colour of the nickel (II) ion?

(1)

b) Deduce the colour of the permanganate ion?

(1)

c) Deduce the colour of the copper (II) ion?

(1)

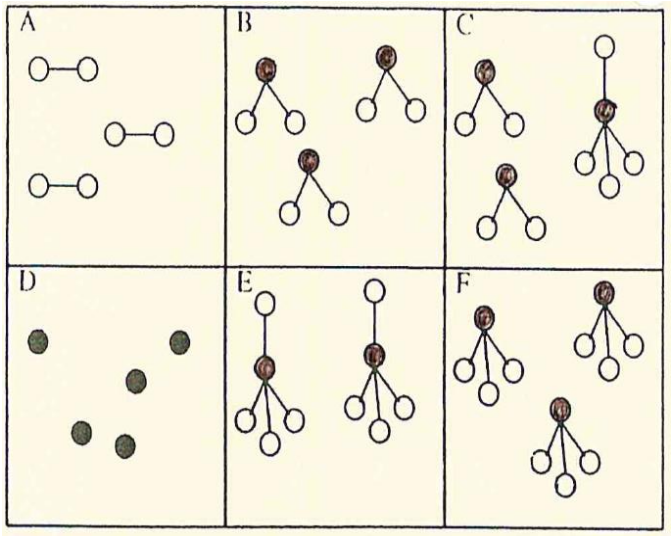
d) Deduce the colour of the chromate ion?

(1)

e) What colour would you expect copper (II) chromate to be?

(1)

9 Use the diagrams below to answer parts ‘a)’ and ‘b)’.



a) Identify the two elements

b) Identify the mixture

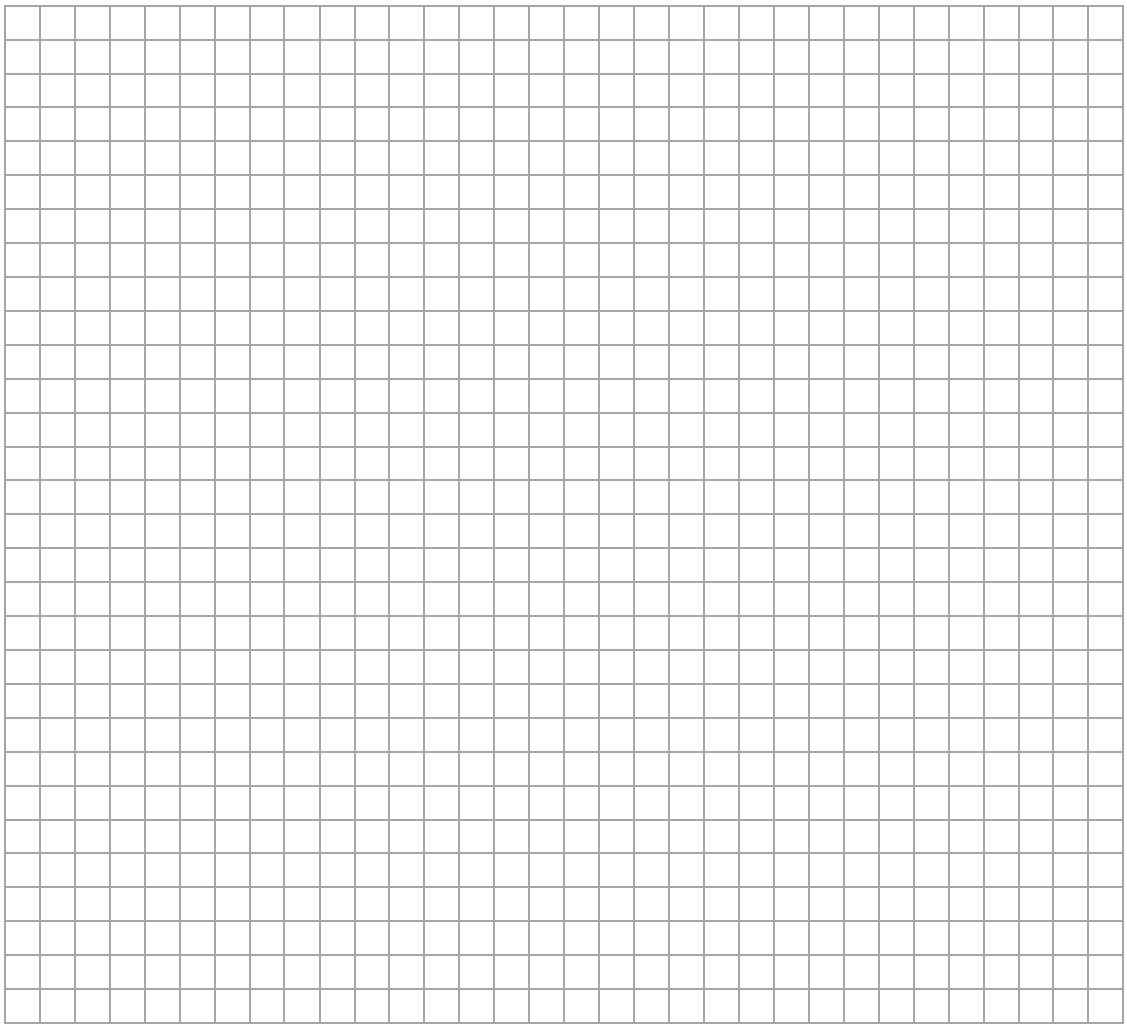
(2)

Total marks (30)

[END OF SECTION B]

[END OF PAPER]

Spare graph paper for question **4 a)**



Paper Notes: 16+ Chemistry Specimen Paper (16+ Chemistry Specimen Paper (2020))

Compiled by SATs-Papers.co.uk to help you get the most from this paper.

Overview

This is the **Rugby School Sixth Form Entrance Examination** in **Chemistry**, sat in **November 2020**. It is designed for candidates applying to enter **Year 12** (16+ entry) and assesses the breadth of **GCSE Chemistry** knowledge expected at the top end of Key Stage 4. The paper lasts **one hour** and is worth **60 marks** in total.

The examination is divided into two sections of equal weighting. **Section A** comprises **30 multiple-choice questions** testing recall, comprehension, and application across the full GCSE syllabus, while **Section B** contains **short-answer questions** requiring written responses, calculations, and the interpretation of experimental data. Both sections must be attempted, and candidates are provided with a **data sheet** and a **periodic table** inside the front cover.

This paper suits high-achieving GCSE students aiming for Sixth Form entry at a selective independent school. The multiple-choice format rewards secure factual knowledge and rapid recall, while the structured questions in Section B assess practical reasoning, numerical fluency, and the ability to analyse unfamiliar contexts. The paper reflects the rigorous standards expected at Rugby and similar institutions.

How this paper is organised

The paper opens with **Section A**, a **30-mark multiple-choice section** containing **30 questions**, each worth one mark. Questions 1 to 25 offer four options (A to D) covering topics such as scientific method, chemical formulae, electron configuration, rates of reaction, the periodic table, bonding, energy changes, reactivity series, percentage composition, atomic structure, pollution, chromatography, pH, changes of state, and separation techniques. **Questions 26 to 30** are matching questions in which candidates select the correct substance from a list of four (water, hydrogen chloride, sodium chloride, diamond) to fit each description.

Section B is also worth **30 marks** and consists of **nine structured questions** of varying length. Question 1 asks candidates to complete a table about atoms (protons, neutrons, electrons), while Question 2 repeats the exercise for ions. Question 3 requires sketching reaction-rate curves for different experimental conditions. Question 4 involves plotting a bar chart from historical data and interpreting trends in fire deaths. Questions 5 to 8 cover corrosion, states of matter, bonding types, and the colours of

transition metal ions, each requiring short written answers or table completion. Question 9 tests understanding of elements, compounds, and mixtures using particle diagrams.

Candidates should bring a **pen, pencil, ruler, and calculator**. Graph paper is provided for Question 4 and spare graph paper is included at the back of the booklet. The layout is clear, with ample white space, and questions are numbered sequentially within each section.

Topics covered

- Scientific method and the distinction between testable and subjective statements (e.g. evaluating claims about smokeless fuels)
- Tests for carbonate ions using dilute hydrochloric acid and observation of gas evolution
- Writing chemical formulae for ionic compounds using electron configuration (e.g. determining the formula of a compound from 2,8,3 and 2,8,6 electron arrangements)
- Factors affecting rates of reaction, including concentration, temperature, and surface area (particle size)
- Group numbers and names in the periodic table, including the alkaline earth metals (Group 2) and the halogens (Group 7)
- Writing formulae for compounds with Roman numeral oxidation states (e.g. niobium(V) oxide)
- Energy changes in exothermic reactions and the relationship between bond strengths and enthalpy change
- The reactivity series of metals and predicting displacement reactions
- Percentage composition by mass calculations for compounds containing potassium
- Atomic structure, including protons, neutrons, electrons, isotopes, and ions of the same element
- Classification of substances as elements, compounds, molecules, or ionic compounds
- Air pollution and identifying pollutant gases (sulfur dioxide, nitrogen dioxide, carbon monoxide) versus non-pollutants
- Chromatography and interpreting chromatograms to identify component dyes in mixtures
- Acids, bases, and neutralisation (e.g. using magnesium hydroxide to neutralise stomach acid)
- Distinguishing single compounds from mixtures (e.g. limestone versus air, seawater, chocolate)
- Trends in physical properties within groups (e.g. predicting the melting point of rubidium from Group 1 data)
- Neutralising alkaline deposits with acidic substances such as vinegar
- pH values and the strength of acids (weak acids such as methanoic acid)
- Environmental chemistry and the role of catalytic converters in reducing vehicle emissions
- Changes of state, including sublimation of dry ice (solid carbon dioxide)

- Counting atoms in chemical formulae, including hydrated salts such as copper(II) sulfate pentahydrate
- Common uses of metals (e.g. aluminium in drink cans)
- Properties of carbon dioxide, including density and solubility
- Interpreting graphs of gas volume against time for metal-acid reactions and using data to determine reaction completion times
- Separation techniques: solution, filtration, crystallisation, evaporation, and their correct sequence for purifying contaminated salts
- Bonding types (giant covalent, ionic, simple molecular) and their relation to boiling points and physical properties
- Completing tables for atoms and ions, including mass number, atomic number, and particle counts
- Sketching and interpreting reaction-rate curves for different temperatures and quantities of reactant
- Analysing experimental data on corrosion and identifying effective protective treatments for iron
- Predicting physical states at room temperature from melting and boiling points
- Deducing the colours of individual ions (e.g. nickel(II), permanganate, copper(II), chromate) from compound colours
- Particle diagrams to distinguish between elements, compounds, and mixtures

How to use this paper for revision

- Revise the **reactivity series** and practise predicting displacement reactions. Know which metals displace others from solution and which corrode more readily in sacrificial protection.
- Memorise the **group names** and numbers on the periodic table, especially Group 1 (alkali metals), Group 2 (alkaline earth metals), Group 7 (halogens), and Group 0 (noble gases).
- Practise writing **formulae for ionic compounds** from electron arrangements. Remember that a metal with three outer electrons forms a 3+ ion, and a non-metal with six outer electrons forms a 2- ion.
- Understand the factors affecting **rates of reaction**: higher concentration, higher temperature, and greater surface area (powdered versus lumps) all increase the rate.
- Learn to calculate **percentage by mass** by dividing the mass of the element by the formula mass of the compound and multiplying by 100. Show all working and use the relative atomic masses provided.
- Revise **separation techniques** and their correct order. To purify contaminated sodium chloride, dissolve it in water, filter out insoluble impurities, then crystallise or evaporate to recover pure salt.
- Study the relationship between **bonding type** and physical properties. Ionic and metallic substances have high melting and boiling points; simple covalent molecules have low melting and boiling points; giant covalent structures have very high melting points.
- Practise interpreting **chromatograms**. A spot that travels the same distance as a reference dye indicates that dye is present in the mixture.
- Learn the **pH scale**. Strong acids have pH 0-2, weak acids pH 3-6, neutral substances pH 7, weak alkalis pH 8-11, and strong alkalis pH 12-14.
- Revise **changes of state**. Sublimation is solid to gas without passing through the liquid phase. Condensation is gas to liquid. Evaporation is liquid to gas. Solidification is liquid to solid.

Common mistakes to avoid

- Confusing **atoms and ions**. An ion has lost or gained electrons, so the number of electrons does not equal the number of protons. Check the charge to work out the electron count.
- Writing incorrect **formulae for ionic compounds**. Remember to balance the charges: a 3+ ion and a 2- ion combine in a 2:3 ratio (e.g. X_2Y_3, not X_3Y_2).
- Choosing the wrong conditions for **slowest reaction rate**. The slowest rate occurs with the lowest concentration, lowest temperature, and largest particle size (lumps, not powder).
- Misidentifying **Group 2** as Group 1 or vice versa. Group 1 contains the alkali metals (lithium, sodium, potassium, rubidium, caesium). Group 2 contains the alkaline earth metals (beryllium, magnesium, calcium, strontium, barium).
- Forgetting that **carbon dioxide is not considered an air pollutant** in the traditional sense of toxic gases, even though it is a greenhouse gas. Pollutants include sulfur dioxide, nitrogen dioxide, and carbon monoxide.
- Misinterpreting **chromatograms**. A dye is present in the ink only if a spot in the ink column matches the height of a reference spot. If no spot matches, that dye is absent.
- Confusing **neutralisation** with other reactions. An acid is neutralised by a base or alkali (e.g. magnesium hydroxide), not by sugar, salt, or another acid such as lemon juice.
- Miscounting atoms in **formulae with brackets**. In $(NH_4)_2SO_4$, the subscript 2 outside the bracket multiplies everything inside: 2 nitrogen, 8 hydrogen, 1 sulfur, 4 oxygen, totalling 15 atoms.
- Mixing up **separation techniques**. Filtration removes insoluble solids from a liquid; crystallisation or evaporation recovers dissolved solids. Use filtration before crystallisation, not after.

Exam technique

Attempt **Section A first** to secure the full 30 marks from multiple-choice questions. Work quickly but carefully, reading each question and all four options before selecting your answer. If a question seems difficult, make an educated guess, mark it, and return to it if time allows.

For **Section B**, read each question carefully and note the mark allocation. A 1-mark question requires a single correct answer or calculation, while 2- or 3-mark questions expect more detail, such as showing working or providing a labelled diagram. When

completing tables, check that your answers are consistent (e.g. mass number equals protons plus neutrons). For graph-sketching questions, label your curves clearly and ensure the shape reflects the conditions described (e.g. a steeper curve for higher temperature).

Allocate your time sensibly. Aim to spend roughly **25 minutes on Section A** and **35 minutes on Section B**, leaving a few minutes at the end to review your answers. If you get stuck on a calculation, move on and return to it later. Always show your working, even if you are unsure of the final answer, as partial credit may be awarded.

What to revise alongside this paper

Candidates should consolidate their understanding of **atomic structure and the periodic table**, including electron shell diagrams, trends in reactivity, and the relationship between group number and outer-shell electrons. Revise **bonding** in depth: ionic, covalent, and metallic, and how bonding determines properties such as melting point, boiling point, electrical conductivity, and solubility.

Strength in **practical chemistry** is essential. Revise common tests for gases (carbon dioxide, hydrogen, oxygen, chlorine), flame tests for metal ions, and precipitation reactions to identify ions in solution. Practise **quantitative chemistry**, including moles, concentration, percentage yield, and limiting reagents, as these skills underpin calculations at A-level.

To progress beyond GCSE, explore **energetics and kinetics** in more detail. Study Hess's law, bond enthalpy calculations, collision theory, and how catalysts work at the molecular level. Read around **industrial chemistry**, such as the Haber process and the Contact process, to understand how equilibrium and rate considerations are balanced in large-scale manufacture.

Key terms

> **Reactivity series**, **Displacement reaction**, **Electron configuration**, **Ionic compound**, **Covalent bond**, **Oxidation state**, **Exothermic reaction**, **Percentage by mass**, **Isotope**, **Ion**, **Chromatography**, **Neutralisation**, **pH**, **Sublimation**, **Giant covalent structure**, **Alkali metal**, **Halogen**, **Hydrated salt**, **Rate of reaction**, **Separation technique**

Name: _____ School: _____

Rugby School

Sixth Form Entrance Examination

Mark Scheme
November 2020

Chemistry

Time allowed: 1 hour

This paper is divided into two sections, both of which must be attempted.
You **must** write your name on the front of this booklet.

Section A: multiple choice (30 marks)
Section B: short answer questions (30 marks)

A Data Sheet and a Periodic Table are provided (inside front cover and first page)

Equipment Required: Pen, pencil, ruler and calculator

For examiner's use only:

Section A	/30
Section B	/30
Total	/ 60

THE PERIODIC TABLE

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	Group																	
1	1 H Hydrogen 1																	4 He Helium 2
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
3	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
4	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	63.5 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
5	86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 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
6	133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 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	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
7	223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key

Relative atomic mass
Symbol
Name
Atomic number

Chemistry Data Sheet

1. Reactivity Series of Metals

Potassium	most reactive
Sodium	
Calcium	
Magnesium	
Aluminium	
Carbon	
Zinc	
Iron	
Tin	
Lead	
Hydrogen	
Copper	
Silver	
Gold	
Platinum	least reactive

(elements in italics, though non-metals, have been included for comparison)

2. Formulae of Some Common Ions

Positive ions		Negative ions	
Name	Formula	Name	Formula
Hydrogen	H^+	Chloride	Cl^-
Sodium	Na^+	Bromide	Br^-
Silver	Ag^+	Fluoride	F^-
Potassium	K^+	Iodide	I^-
Lithium	Li^+	Hydroxide	OH^-
Ammonium	NH_4^+	Nitrate	NO_3^-
Barium	Ba^{2+}	Oxide	O^{2-}
Calcium	Ca^{2+}	Sulfide	S^{2-}
Copper(II)	Cu^{2+}	Sulfate	SO_4^{2-}
Magnesium	Mg^{2+}	Carbonate	CO_3^{2-}
Zinc	Zn^{2+}		
Lead	Pb^{2+}		
Iron(II)	Fe^{2+}		
Iron(III)	Fe^{3+}		
Aluminium	Al^{3+}		

Marking Grid for Section A

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

Section A

You should complete this section using the answer grid provided.

1 Below are some statements regarding the smokeless fuels *Burnbrite* and *Hiheat*. Which of these statements **cannot** be checked scientifically?

A *Burnbrite* produces less ash than *Hiheat*
B ***Hiheat* is a better solid fuel than *Burnbrite***
C 1 kg of *Burnbrite* produces more heat when it is burned than 1 kg of *Hiheat*
D *Burnbrite* produces more sulfur dioxide than *Hiheat*

2 When a geologist tested a sample of copper ore with dilute hydrochloric acid, a gas was given off. This suggests the ore could contain…

A **$CuCO_3$**
B $CuCl_2$
C $CuSO_4$
D $Cu(OH)_2$

3 A metal atom X has the electron arrangement 2,8,3 and a non-metal atom Y has the electron arrangement 2,8,6. What is the correct formula for the compound formed between elements X and Y?

A X_2Y
B XY
C XY_2
D **X_2Y_3**

4 Hydrochloric acid reacts with iron (II) sulfide to produce hydrogen sulfide gas. Under which of the following sets of conditions would the reaction start at the **slowest** rate?

	Concentration of acid (mol/dm^3)	Temperature (^oC)	State of iron (II) sulfide
A	1.0	15	Powdered
B	0.1	30	Powdered
C	**0.1**	**15**	**Lumps**
D	2.0	30	Lumps

5 What group number of the periodic table are the Alkaline Earth Metals in?

A **2**
B 0
C 1
D 7

6 Which of the following is the correct formula for niobium (V) oxide

A Nb_5O
B NbO_5
C Nb_5O_2
D **Nb_2O_5**

7 Many chemical reactions produce energy because…

A the reactants must be heated for the reaction to begin
B bonds have broken during the reaction
C the products have weaker bonds than the reactants
D **the energy content of the products is less than that of the reactants**

8 Magnesium is more reactive than zinc. This means that…

A zinc will displace magnesium from a solution of magnesium sulfate
B zinc will corrode in preference to magnesium
C magnesium displaces chlorine from potassium chloride (aq), but zinc will not
D **magnesium forms ions more readily than zinc**

9 Which one of the following contains the greatest percentage by mass of potassium?

(relative atomic masses: H = 1, C = 12, O = 16, K = 39)

A **KOH**
B $KHCO_3$
C K_2CO_3
D $K_2C_2O_4$

10 This question refers to the two particles **X** and **Y**. The table shows some data for X and Y.

	Particle **X**	Particle **Y**
Number of protons	26	26
Number of neutrons	30	31
Number of electrons	24	23

Particles **X** and **Y** are…

A atoms of the same element
B atoms of different elements
C **ions of the same element**
D ions of different elements

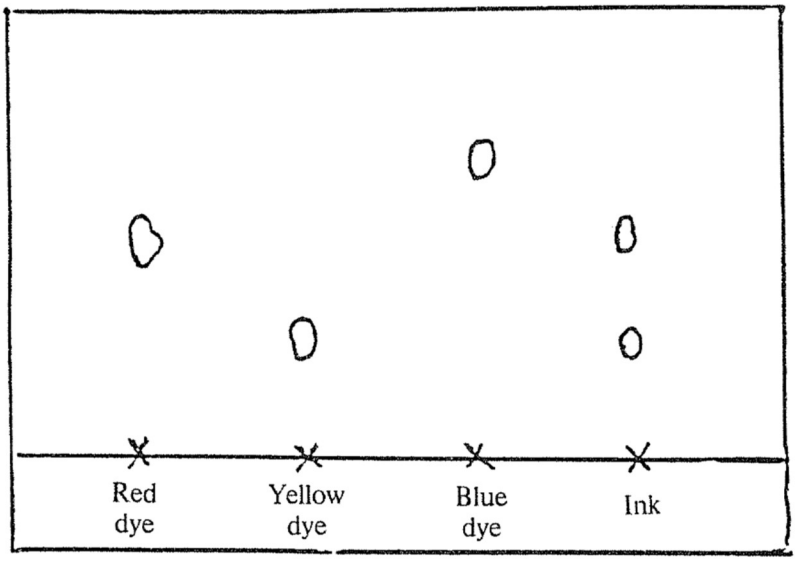
11 Sodium chloride is…

A an element
B a molecule
C a compound of two non-metals
D **a compound of a metal and a non-metal**

12 Which of the following gases is not considered to be a cause of air pollution?

A sulfur dioxide
B nitrogen dioxide
C carbon monoxide
D **carbon dioxide**

13 The diagram of a chromatogram shows the dyes present in an ink. Spots of red, yellow and blue dyes were used as well as the ink.



The ink contained…

A blue and yellow dyes.
B red dye only.
C **red and yellow dyes.**
D yellow, red and blue dyes.

14 Indigestion is caused by the presence of an excess of acid in the stomach. Which of the following substances could an indigestion tablet contain to neutralise this acid?

A **magnesium hydroxide**
B sugar
C sodium chloride
D lemon juice

15 Which of the following is a single compound?

A air
B seawater
C **limestone**
D chocolate

16 The table below shows the melting points of the elements in Group 1. The melting point of rubidium is missing.

Element	Li	Na	K	Rb	Cs
Melting Point (°C)	180	98	64		29

The most likely melting point of rubidium is…

A 31 °C
B 55 °C
C **39 °C**
D 115 °C

17 Newly laid bricks sometimes become coated with an alkaline white deposit. The best way to remove this deposit is to wash it with a mixture of detergent and a chemical that will react with the white deposit.

Which one of the following could be used with the detergent in the mixture?

A **vinegar**
B limewater
C sodium hydroxide solution
D ethanol

18 Methanoic acid (a weak acid) is present in many kettle/steam iron descalers. What pH would you expect a solution of methanoic acid to have?

A 1
B 13
C 7
D **5**

19 Pollution of the environment is reduced by…

A burning coal in power stations
B adding fertilisers to the soil
C **replacing metal items with plastic items**
D using a catalytic converter on a car exhaust

20 Which change of state occurs when dry ice (solid carbon dioxide) is heated and converted into a gas for stage effects?

A condensation
B sublimation
C evaporation
D solidification

21 Which of the following compounds contains the largest number of atoms?

A	aluminium oxide	Al_2O_3
B	ammonium sulfate	$(NH_4)_2SO_4$
C	calcium nitrate	$Ca(NO_3)_2$
D	**hydrated copper(II) sulfate crystals**	**$CuSO_4.5H_2O$**

22 The metal most commonly used for a drink can is…

A aluminium
B iron
C tin
D copper

23 Carbon dioxide is a gas which…

A is insoluble in water
B makes up 0.93% of earth's atmosphere
C burns in air
D is more dense than air

24 2.0 g of magnesium metal were reacted with an excess of dilute sulphuric acid. The volume of gas given off was measured at one minute intervals. The results of this experiment are shown in the table below:

Time (min)	0	1	2	3	4	5	6	7	8	9	10
Volume (cm^3)	0	16	25	35	40	44	47	49	50	50	50

The time needed for 1.0 g of magnesium to react was

A 1 minutes
B **2 minutes**
C 4 minutes
D 8 minutes

25 A sample of sodium chloride has become contaminated with dust. What sequence of operations is the best way to obtain pure sodium chloride?

A solution, crystallisation, filtration
B decantation, solution, precipitation
C solution, filtration, crystallisation
D **solution, filtration, evaporation**

Questions 26 – 30, choose from the list A to D

A Water (H_2O)
B Hydrogen chloride (HCl)
C Sodium chloride (NaCl)
D Diamond (C)

26 The substance that has a giant covalent structure
D **Diamond (C)**

27 The substance that consists of ions in a giant structure
C **Sodium chloride (NaCl)**

28 The substance which boils at -85 ^{0}C
B **Hydrogen chloride (HCl)**

29 The substance that forms dense white fumes with ammonia gas
B **Hydrogen chloride (HCl)**

30 The substance that contains no covalent bonds
C **Sodium chloride (NaCl)**

Total marks (30)

[END OF SECTION A]

Section B

1 Complete the following table for the atoms shown

Element	Symbol	Atomic Number	Mass Number	Protons	Neutrons	Electrons
Sodium	Na	11	23	11	12	11
Aluminium	Al	13	27	13	14	13
Fluorine	F	9	19	9	10	9
Potassium	K	19	39	19	20	19

(2)

2 Copy and complete the following table for the ions shown

Ion	Symbol	Atomic Number	Mass Number	Protons	Neutrons	Electrons
Lithium	Li^{+}	3	7	3	4	2
Oxide	O^{2-}	8	16	8	8	10
Magnesium	Mg^{2+}	12	24	12	12	10
Phosphide	P^{-3}	15	31	15	16	18

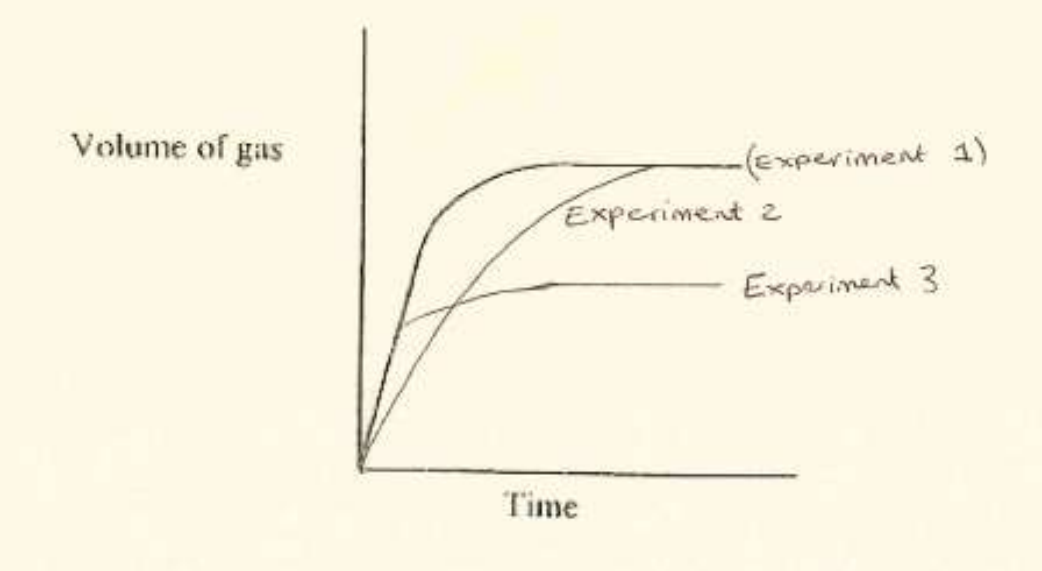
(2)

3 A company which produces sweets was introducing a new product called "Moon Dust". This sweet was in the form of a powder, which fizzed in water. The fizziness was investigated before it was put on the market.

Three different experiments were carried out.

Experiment	Mass of powder added to 1 litre of water	Temperature (°C)
1	40	25
2	40	37
3	20	25

For each experiment, a graph was plotted of the volume of gas produced against time. The graph for experiment 1 is shown below.



On the graph above, sketch the plots for experiments 2 and 3 on to it. Label each curve clearly.

1 mark for each correct line drawn (for Experiment 2 and 3)

(2)

4 In 1926 the plastic *Polysynth* was invented and immediately used in household furniture. The material was found to generate poisonous fumes when burnt. The fire services kept the following statistics.

Year	*Polysynth* used in household furniture (tons)	Household fire deaths
1910	0	10
1920	0	10
1930	1000	12
1940	4000	18
1950	7000	24
1960	10000	30
1970	10000	30
1980	0	10

a) Use the graph paper below to plot a bar chart of household deaths against year.

The grid below is 32 squares wide and 30 squares high. Spare graph paper is provided on the back page.

Correct x axis and title = 1 mark
Correct y axis and title = 1 mark
Correct plotted bar chart points = 1 mark

b) Describe the relationship between the quantity of plastic used and the number of household fire deaths from fumes?

As the quantity of plastic used **increases**, the number of household fire death increases.
Mention of **positive correlation**/ state one variable increases the other

(1)

c) What evidence is there in the statistics that not all fire deaths were due to *Polysynth*?

In **1910**, **1920** and **1980**, there were **still deaths** despite no plastic being used.

(1)

5 The corrosion of iron was investigated by giving six identical iron nails different treatments. A seventh nail was left untreated. All seven nails were then left exposed to the atmosphere for several days.

The results of the experiment are given below.

Nail	Treatment	Cost of treatment	Initial mass of nail (g)	Final mass of nail (g)
A	waxed	low	5.0	5.3
B	oiled	low	5.0	4.1
C	chromium plated	high	5.0	5.0
D	painted	low	5.0	5.4
E	galvanised	high	5.0	5.1
F	salted	low	5.0	6.7
G	untreated	nil	5.0	6.1

a) What happens to the mass of a nail when it corrodes?
Increases

(1)

b) Which nail was weighed incorrectly after exposure to the atmosphere?
B

(1)

c) Which nail was best protected against corrosion?
C

(1)

d) Which nail received a treatment which made corrosion much worse?
F

(1)

6 **a)** Complete the following table. Use the words *solid*, *liquid* or *gas*.

Element	Melting point (°C)	Boiling point (°C)	Physical State at 25 ^{0}C
Iron	1535	2750	Solid
Fluorine	-220	-188	Gas
Mercury	-39	357	Liquid
Iodine	114	184	Solid
Nitrogen	-210	-196	Gas
Sodium	98	883	Solid
Bromine	-7	59	Liquid
Xenon	-112	-107	Gas

8 correct = 2 marks
7 correct = 1 mark
6 correct = 0 marks (2)

b) What is the name given to the elements in group 1?
Alkali metals

(1)

c) What is the name given to the elements in group 7?
Halogens

(1)

d) Explain why elements in the same group exhibit similar chemical properties.
Same number of outer electrons

(1)

7 Complete the following table. Use the words *metallic*, *ionic* or *covalent*.

Substance	Melting point (°C)	Boiling point (°C)	Type of bonding
Nitrogen	-210	-196	Covalent
Sodium	98	883	Metallic
Sulfur dioxide	-73	-10	Covalent
Water	0	100	Covalent
Ethane	-183	-88	Covalent
Magnesium chloride	712	1418	Ionic

(3)

All 6 correct = 3 marks
5 correct = 2 marks
3 correct = 1 mark
2 correct = 0 marks

8 Using the table below to answer the following questions.

Ionic Compound	Colour
Potassium chromate	Yellow
Sodium chloride	White
Nickel (II) sulfate	Green
Sodium chromate	Yellow
Copper (II) chloride	Blue
Potassium chloride	White
Potassium permanganate	Purple
Nickel (II) chloride	Green

a) Deduce the colour of the nickel (II) ion?
Green (1)

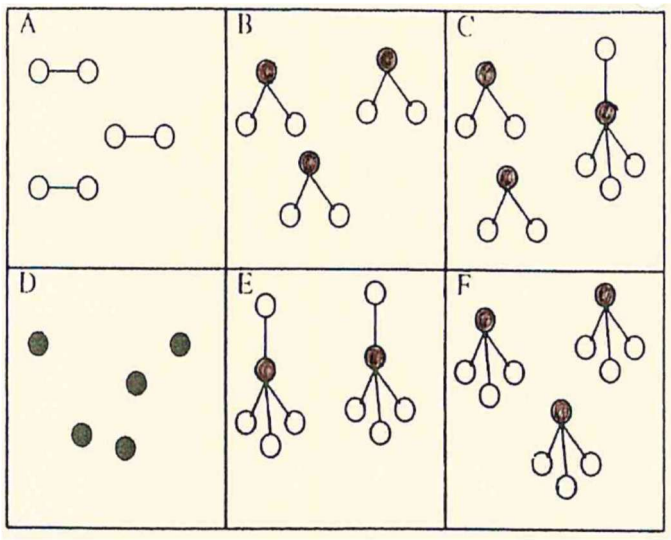
b) Deduce the colour of the permanganate ion?
Purple (1)

c) Deduce the colour of the copper (II) ion?
Blue (1)

d) Deduce the colour of the chromate ion?
Yellow (1)

e) What colour would you expect copper (II) chromate to be?
Green (accept green in answer) or blue/yellow (1)

9 Use the diagrams below to answer parts ‘a)’ and ‘b)’.



a) Identify the two elements

A and D

b) Identify the mixture

C

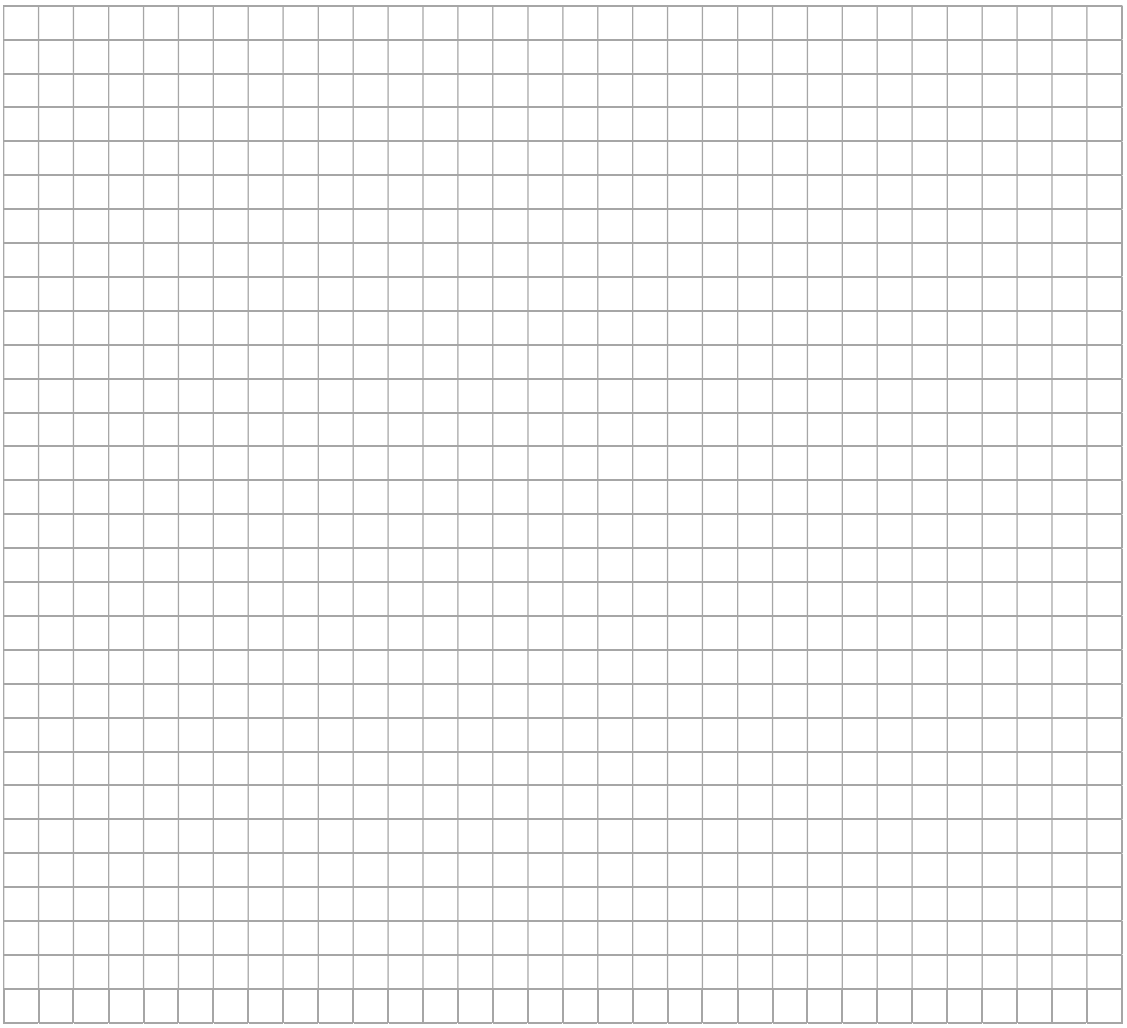
(2)

Total marks (30)

[END OF SECTION B]

[END OF PAPER]

Spare graph paper for question **4 a)**



Answer-Key Notes: 16+ Chemistry Mark Scheme (16+ Chemistry Mark Scheme (2020))

Compiled by SATs-Papers.co.uk to help you mark this paper and learn from each answer.

How to use this answer key

Use this mark scheme to score the paper objectively, question by question. Award marks only when the answer given matches the mark scheme exactly (except where alternative phrasings are noted in Section B). For Section A, mark every multiple-choice answer as correct or incorrect with no partial credit.

Once you have totalled the score, distinguish between careless slips and genuine knowledge gaps. A student who correctly identifies 'sublimation' but misreads the data table on Group 1 melting points has made a careless error. A student who consistently chooses incorrect ion colours or cannot balance formula subscripts needs to revisit core content.

The worked examples below provide reasoning for selected questions where students often lose marks despite understanding the underlying concept. Consult them when you need to explain **why** an answer is correct, not merely what the correct answer is.

Score interpretation

A raw score near 55–60/60 indicates very strong preparation; the student has command of GCSE core concepts and is ready for AS-level material. Scores in the 45–54 range show solid understanding with a few weak spots (often atomic structure notation, formula writing or interpreting data tables). Review those topics before term starts.

Scores in the 30–44 range suggest patchy recall of key ideas (electron configurations, bonding types, pH scales). The student should consolidate GCSE chemistry over the summer using a revision guide and past papers. Scores below 30 indicate significant gaps; consider whether the student has covered the full GCSE specification, and arrange catch-up sessions in the first half of autumn term.

Section A contributes half the total; students who score well on multiple-choice but lose many marks in Section B often understand concepts but struggle with written explanations or numerical working. The reverse pattern (strong Section B, weak Section A) is less common but can point to exam technique issues such as misreading questions under time pressure.

Worked examples

Section A: Multiple choice, Q1–30

Each question is worth one mark; there is no negative marking. Students lose easy marks when they misread qualifiers such as 'not', 'slowest' or 'least'. For example, Q12 asks which gas is **not** considered a pollutant, yet many students overlook the word 'not' and choose sulfur dioxide. Similarly, Q1 turns on the word 'scientifically'; only option B is a subjective value judgement. Train students to underline key words before selecting an answer.

Q2 : A ($CuCO_3$)

Dilute hydrochloric acid reacts with carbonates to produce carbon dioxide gas. Of the four copper compounds listed, **only copper carbonate** will effervesce with HCl. Copper chloride is already a chloride (no gas), copper sulfate and copper hydroxide react but do not produce a gas that would be 'given off' in an obvious fizzing reaction.

Q3 : D (X_2Y_3)

Element X (configuration 2,8,3) is in Group 3 and forms X^{3+} ions. Element Y (configuration 2,8,6) is in Group 6 and forms Y^{2-} ions. To balance charges, you need two X^{3+} ions (total +6) and three Y^{2-} ions (total −6), giving the formula $\mathbf{X_2Y_3}$. Many students write XY_2 by mistakenly pairing the group numbers rather than balancing ionic charges.

Q4 : C (0.1 mol/dm³, 15 °C, lumps)

Reaction rate increases with concentration, temperature and surface area. The **slowest** rate will therefore use the lowest concentration (0.1 mol/dm^3), the lowest temperature (15 °C) and the smallest surface area (lumps rather than powder). Option C combines all three factors that minimise rate.

Q9 : A (KOH)

Calculate the percentage by mass of potassium in each compound. KOH has M_r = 39 + 16 + 1 = 56, so %K = (39 ÷ 56) × 100 ≈ 69.6%. For $KHCO_3$ (M_r = 100), %K = 39%. For K_2CO_3 (M_r = 138), %K = (78 ÷ 138) × 100 ≈ 56.5%. For $K_2C_2O_4$ (M_r = 166), %K ≈ 47%. **KOH has the highest percentage** because it has the smallest molar mass for a given 39 g of potassium.

Q16 : `C (39 °C)`

Melting points in Group 1 decrease down the group: Li (180 °C), Na (98 °C), K (64 °C), then Rb, then Cs (29 °C). Rubidium sits between K and Cs, so its melting point must lie between 64 °C and 29 °C. Only option C (39 °C) falls in that range. Options A and B are below Cs; option D is above K.

Q20 : `B (sublimation)`

Sublimation is the direct change from solid to gas without passing through the liquid phase. Dry ice (solid CO_2) sublimes at atmospheric pressure, which is why it is used for stage fog. Evaporation describes liquid → gas, and condensation is the reverse. **Sublimation** is the only term that applies to solid → gas.

Section B: Atomic structure, Q1–2

These questions test whether students can extract protons, neutrons and electrons from atomic and mass numbers, and apply the same logic to ions. Award marks only if every cell in the row is correct. The most common error is writing the **mass number** in the 'neutrons' column instead of subtracting the atomic number. For ions, students often forget to adjust the electron count by the charge.

Q1 (Aluminium row) : `Symbol Al, Atomic number 13, Mass number 27, Protons 13, Neutrons 14, Electrons 13`

Atomic number 13 means 13 protons (and 13 electrons in a neutral atom). Mass number 27 = protons + neutrons, so neutrons = 27 − 13 = **14**. Many students write 27 in the neutrons column by mistake.

Q2 (Oxide ion O^{2-}) : `Symbol O²⁻, Atomic number 8, Mass number 16, Protons 8, Neutrons 8, Electrons 10`

Oxygen has atomic number 8 (8 protons). The 2− charge means the ion has gained two electrons, so electrons = 8 + 2 = **10**. Neutrons = 16 − 8 = 8. Students who write 8 electrons have forgotten to add the charge.

Section B: Rates of reaction, Q3

This question rewards understanding that higher temperature and greater mass of reactant both increase the rate and total volume of gas produced. Award one mark for each correctly drawn and labelled curve. Experiment 2 (higher temperature) should reach the same final volume as Experiment 1 but faster (steeper initial slope). Experiment 3 (half the mass) should plateau at half the final volume.

Q3 (Experiment 2) : `Curve starts steeper than Experiment 1, reaches the same final volume, labelled 'Experiment 2'`

Increasing temperature from 25 °C to 37 °C increases the rate of reaction (more frequent collisions with energy above E_a). The **same mass** of powder is used, so the same total volume of gas is produced, but it is produced more quickly. The curve should therefore rise faster but plateau at the same height as the given curve.

Q3 (Experiment 3) : `Curve plateaus at roughly half the final volume of Experiment 1, labelled 'Experiment 3'`

Using 20 g instead of 40 g means half as much reactant, so **half the total gas** is produced. Temperature is the same as Experiment 1, so the initial slope is similar. The curve should level off at approximately half the height of Experiment 1.

Section B: Interpreting data (Polysynth), Q4

Part (a) tests graph-drawing skills: correct axes, labels, and accurate bar heights. Award one mark for each of the three graph elements (x-axis labelled 'Year', y-axis labelled and scaled for deaths 0–30, bars plotted correctly at 10, 10, 12, 18, 24, 30, 30, 10). Parts (b) and (c) require students to describe correlation and identify that deaths occurred even when no plastic was used, showing other causes existed.

Q4(b) : `As the quantity of plastic used increases, the number of household fire deaths increases. (Accept 'positive correlation' or similar.)`

From 1930 to 1960, both plastic use and deaths rise together. This **positive correlation** suggests plastic fumes contributed to deaths, though it does not prove causation (other factors may also have changed). Award the mark for any statement that one variable increases with the other.

Q4(c) : `In 1910, 1920 and 1980, there were still deaths (10 each year) despite no plastic being used.`

If Polysynth were the only cause, deaths would be zero in years with zero plastic. The baseline of 10 deaths in 1910, 1920 and 1980 shows that **other causes** (ordinary fires, other materials) also contributed. Award the mark for identifying any year with zero plastic but non-zero deaths.

Section B: Metals and corrosion, Q5

This practical-data question tests understanding that corrosion (oxidation) increases mass because oxygen is added to the iron. Students must also identify anomalies (Nail B lost

mass, suggesting a weighing error) and compare treatments. Award one mark per part; answers must match the table data, not prior knowledge of which treatment 'should' work best.

> **Q5(a)** : `Increases`
>
> Iron corrodes to form iron oxide (rust), which has greater mass than pure iron because oxygen atoms have been added. Six of the seven nails show a mass increase. (Nail B is an outlier, addressed in part b.)

> **Q5(b)** : `B (oiled)`
>
> Nail B is the only one whose final mass (4.1 g) is **less than** the initial mass (5.0 g). This is physically impossible for corrosion and indicates a weighing or recording error.

> **Q5(c)** : `C (chromium plated)`
>
> Nail C is the only one whose mass did not change (5.0 g → 5.0 g). This means **no corrosion occurred**, so chromium plating provided complete protection. Other treatments slowed corrosion but did not eliminate it.

Section B: States of matter, groups and bonding, Q6–8

Question 6 tests knowledge of melting/boiling points and the ability to deduce physical state at 25 °C. Question 7 asks students to link melting and boiling points to bonding type (ionic and metallic substances have high values; covalent molecules have low values). Question 8 tests reasoning about ion colours from compound data. Award marks generously if the logic is sound, even if one cell is wrong due to a misreading.

> **Q6(a) – Iodine** : `Solid`
>
> Iodine melts at 114 °C and boils at 184 °C. At 25 °C (below the melting point), iodine is a **solid**. Students who write 'gas' have confused iodine with a Group 7 element at the top of the group (fluorine or chlorine).

> **Q7 – Water** : `Covalent`
>
> Water has a low melting point (0 °C) and boiling point (100 °C) relative to ionic or metallic substances. These are characteristic of **covalent molecular** structures, where intermolecular forces (hydrogen bonds in water's case) are much weaker than the covalent bonds within each molecule.

Q8(e) : `Green (or blue/yellow)`

Copper(II) ion is blue (deduced from copper(II) chloride). Chromate ion is yellow (deduced from potassium chromate and sodium chromate). Mixing blue and yellow gives **green**, so copper(II) chromate should appear green. Accept 'blue and yellow' or 'blue/yellow' if the student has not mixed the colours.

Section B: Elements, compounds and mixtures, Q9

This question uses particle diagrams to distinguish elements (one type of particle), compounds (particles made of different atoms bonded together) and mixtures (more than one type of particle, not bonded). Award one mark for part (a) if both elements (A and D) are identified, and one mark for part (b) if the mixture (C) is identified. No partial credit.

Q9(a) : `A and D`

Diagram A shows diatomic molecules of a single element (all particles identical). Diagram D shows separate atoms of a single element. **Both are elements** because each contains only one type of atom. Diagrams B, C, E and F all contain compounds or mixtures.

Q9(b) : `C`

Diagram C contains two different types of particle: some with black centres and white satellites, others with only white satellites. Because the particles are not all the same, C is a **mixture**. (Diagram F also looks mixed but contains fewer distinct particle types; C is the clearer example.)

Next steps

After marking, sit with the student and review every incorrect answer. For Section A, ask the student to explain **why** they chose their answer; this often reveals whether the mistake was a misreading or a conceptual gap. For Section B, check working in the margin; if the method is sound but the final answer is wrong, the issue is usually arithmetic or a transcription error rather than weak chemistry.

If the score is below 40, prioritise revision of GCSE core content (atomic structure, the periodic table, bonding types, and acid–base reactions) before attempting AS-level material. If the score is 40–50, identify the two or three weakest topics and work through targeted exercises over the summer. Scores above 50 indicate readiness for Sixth Form; extend learning by exploring pre-reading for the AS specification (equilibrium, organic mechanisms, redox titrations) so that term starts at pace.