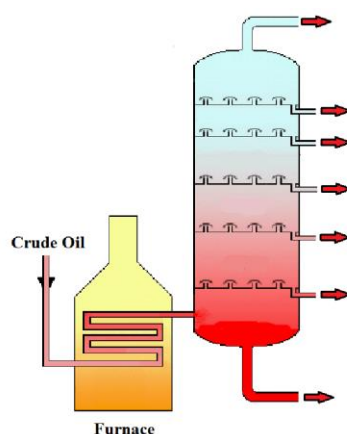
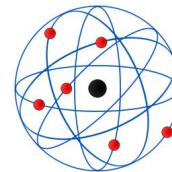


Unit 1 Past Paper Questions



																		104
1																	2	
H																	He	
3	4															10		
Li	Be															Ne		
5	6	7	8	9											18			
B	C	N	O	F											Ar			
11	12	13	14	15	16	17									36			
Na	Mg	Al	Si	P	S	Cl	Ar									Kr		
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	
Cs	Ba	*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	
Fr	Ra	*	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo	
																		119
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71				
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103				
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr				

Unit 1 – Chemical Changes and Structure



SECTION 1

1. In a reaction, 60 cm^3 of hydrogen gas was collected in 20 s.

What is the average rate of reaction, in $\text{cm}^3 \text{ s}^{-1}$, over this time?

A $\frac{60}{20}$

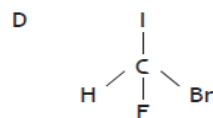
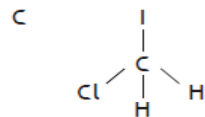
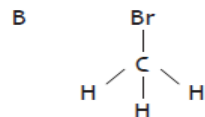
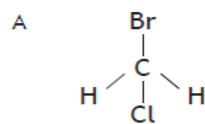
B $\frac{20}{60}$

C $\frac{1}{60}$

D $\frac{1}{20}$

2. Molecules in which four different atoms are attached to a carbon atom are said to be chiral.

Which of the following molecules is chiral?



3. What is the charge on the zinc ion in the compound zinc phosphate $\text{Zn}_3(\text{PO}_4)_2$?

A $2+$

B $3+$

C $2-$

D $3-$



This equation will be balanced when

- A $x = 1$ and $y = 2$
- B $x = 2$ and $y = 2$
- C $x = 3$ and $y = 2$
- D $x = 2$ and $y = 3$.

5. An acidic solution contains

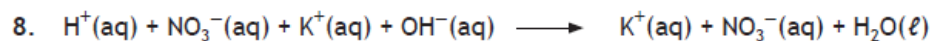
- A only hydrogen ions
- B only hydroxide ions
- C more hydrogen ions than hydroxide ions
- D more hydroxide ions than hydrogen ions.

6. Which of the following oxides, when shaken with water, would give an alkaline solution?

- A Calcium oxide
- B Nickel oxide
- C Nitrogen dioxide
- D Sulfur dioxide

7. Which of the following compounds is not a salt?

- A Calcium nitrate
- B Sodium chloride
- C Potassium sulfate
- D Magnesium hydroxide



The spectator ions present in the reaction above are

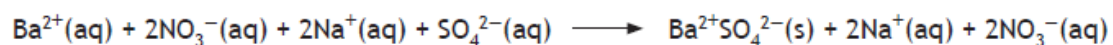
- A $\text{K}^+(\text{aq})$ and $\text{NO}_3^-(\text{aq})$
- B $\text{K}^+(\text{aq})$ and $\text{H}^+(\text{aq})$
- C $\text{OH}^-(\text{aq})$ and $\text{NO}_3^-(\text{aq})$
- D $\text{H}^+(\text{aq})$ and $\text{OH}^-(\text{aq})$.

9.

A reaction is endothermic if

- A energy is required to start the reaction
- B heat is released during the reaction
- C the temperature drops during the reaction
- D the temperature rises during the reaction.

10.



The type of reaction represented by the equation above is

- A addition
- B displacement
- C neutralisation
- D precipitation.

11.

An atom has 26 protons, 26 electrons and 30 neutrons.

The atom has

- A atomic number 26, mass number 56
- B atomic number 56, mass number 30
- C atomic number 30, mass number 26
- D atomic number 52, mass number 56.

12.

The table shows the numbers of protons, electrons and neutrons in four particles, W, X, Y and Z.

<i>Particle</i>	<i>Protons</i>	<i>Electrons</i>	<i>Neutrons</i>
W	17	17	18
X	11	11	12
Y	17	17	20
Z	18	18	18

Which pair of particles are isotopes?

- A W and X
- B W and Y
- C X and Y
- D Y and Z

13.

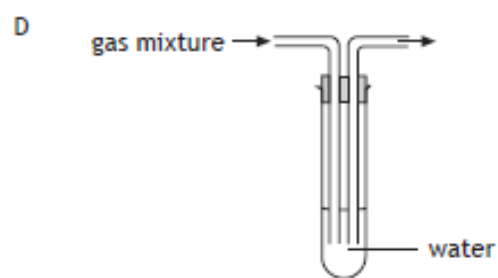
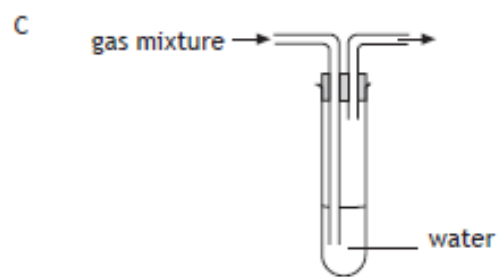
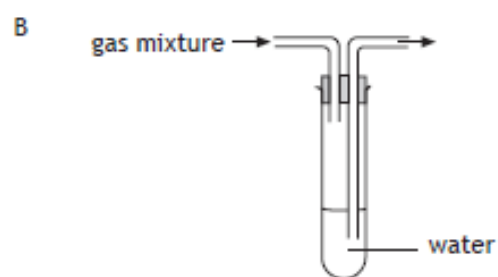
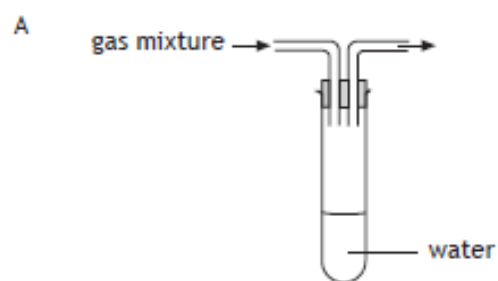
Which of the following particles contains a different number of electrons from the others?

You may wish to use the data booklet to help you.

- A Cl^-
- B S^{2-}
- C Ar
- D Na^+

14.

Which of the following diagrams shows the apparatus which would allow a soluble gas to be removed from a mixture of gases?



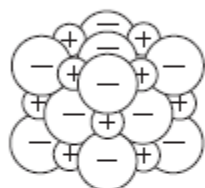
15.

Which of the following diagrams could be used to represent the structure of a covalent network?

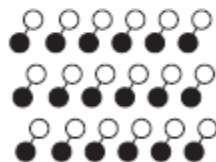
A



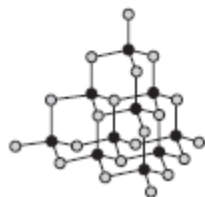
B



C



D



16.

What is the charge on the chromium ion in CrCl_3 ?

A 1+

B 1-

C 3+

D 3-

17.

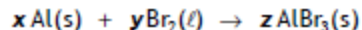
The table contains information about calcium and calcium chloride.

	<i>Melting point</i> (°C)	<i>Density</i> (g cm ⁻³)
Calcium	842	1.54
Calcium chloride	772	2.15

When molten calcium chloride is electrolysed at 800 °C the calcium appears as a

- A solid at the bottom of the molten calcium chloride
- B liquid at the bottom of the molten calcium chloride
- C solid on the surface of the molten calcium chloride
- D liquid on the surface of the molten calcium chloride.

18.



This equation will be balanced when

- A $x = 1$, $y = 2$ and $z = 1$
- B $x = 2$, $y = 3$ and $z = 2$
- C $x = 3$, $y = 2$ and $z = 3$
- D $x = 4$, $y = 3$ and $z = 4$.

19.

0.2 mol of a gas has a mass of 12.8 g.

Which of the following could be the molecular formula for the gas?

- A SO₂
- B CO
- C CO₂
- D NH₃

20.

Which of the following oxides, when shaken with water, would leave the pH unchanged?

You may wish to use the data booklet to help you.

- A Carbon dioxide
- B Copper oxide
- C Sodium oxide
- D Sulfur dioxide

21.

Which compound would not neutralise hydrochloric acid?

- A Sodium carbonate
- B Sodium chloride
- C Sodium hydroxide
- D Sodium oxide

22.

Metallic bonding is a force of attraction between

- A negative ions and positive ions
- B a shared pair of electrons and two nuclei
- C positive ions and delocalised electrons
- D negative ions and delocalised electrons.

23.

Sodium sulfate solution reacts with barium chloride solution.



The spectator ions present in this reaction are

- A Na^+ and Cl^-
- B Na^+ and SO_4^{2-}
- C Ba^{2+} and Cl^-
- D Ba^{2+} and SO_4^{2-} .

24.

Which of the following solutions would produce a precipitate when mixed together?

You may wish to use the data booklet to help you.

- A Ammonium chloride and potassium nitrate
- B Zinc nitrate and magnesium sulfate
- C Calcium nitrate and nickel chloride
- D Sodium iodide and silver nitrate

25.

The table shows the colours of some ionic compounds in solution.

<i>Compound</i>	<i>Colour</i>
copper sulfate	blue
copper chromate	green
potassium chloride	colourless
potassium chromate	yellow

The colour of the chromate ion is

- A blue
- B green
- C colourless
- D yellow.

26.

When solid sodium chloride dissolves in water, a solution containing sodium ions and chloride ions is formed.

Which of the following equations correctly shows the state symbols for this process?

- A $\text{NaCl(s)} + \text{H}_2\text{O(l)} \longrightarrow \text{Na}^+(\text{l}) + \text{Cl}^-(\text{l})$
- B $\text{NaCl(s)} + \text{H}_2\text{O(aq)} \longrightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
- C $\text{NaCl(aq)} + \text{H}_2\text{O(l)} \longrightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
- D $\text{NaCl(s)} + \text{H}_2\text{O(l)} \longrightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$

27.

The table shows the times taken for 0.5 g of magnesium to react completely with acid under different conditions.

<i>Acid concentration</i> (mol l ⁻¹)	<i>Temperature</i> (°C)	<i>Reaction time</i> (s)
0.1	20	80
0.1	25	60
0.2	30	20
0.2	40	10

The time for 0.5 g of magnesium to react completely with 0.2 mol l⁻¹ acid at 25 °C will be

- A less than 10 s
- B between 10 s and 20 s
- C between 20 s and 60 s
- D more than 80 s.

28.

When an atom X of an element in Group 1 reacts to become X^+

- A the mass number of X decreases
- B the atomic number of X increases
- C the charge of the nucleus increases
- D the number of occupied energy levels decreases.

29.

Which of the following does not contain covalent bonds?

- A Sulfur
- B Copper
- C Oxygen
- D Hydrogen

30.

Which line in the table shows the properties of an ionic substance?

	<i>Melting point (°C)</i>	<i>Boiling point (°C)</i>	<i>Conducts electricity</i>	
			<i>Solid</i>	<i>Liquid</i>
A	19	80	no	no
B	655	1425	no	no
C	1450	1740	no	yes
D	1495	2927	yes	yes

31.

What is the name of the compound with the formula Ag_2O ?

- A Silver(I) oxide
- B Silver(II) oxide
- C Silver(III) oxide
- D Silver(IV) oxide

32.

An element was burned in air. The product was added to water, producing a solution with a pH less than 7. The element could be

- A tin
- B zinc
- C sulfur
- D sodium.

33.

When methane burns in a plentiful supply of air, the products are

- A carbon and water
- B carbon dioxide and water
- C carbon monoxide and water
- D carbon dioxide and hydrogen.

34.

In a reaction, the mass lost in 30 seconds was 2 g.

What is the average rate of reaction, in g s^{-1} , over this time?

- A $\frac{1}{30}$
- B $\frac{30}{2}$
- C $\frac{1}{2}$
- D $\frac{2}{30}$

35.

An atom has 21 protons, 21 electrons and 24 neutrons.

The atom has

- A atomic number 24 and mass number 42
- B atomic number 45 and mass number 21
- C atomic number 21 and mass number 45
- D atomic number 24 and mass number 45.

36.

What is the charge on the zinc ion in zinc dichromate, ZnCr_2O_7 ?

You may wish to use the data booklet to help you.

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

37.

The table contains information about magnesium and magnesium chloride.

	Melting Point ($^{\circ}\text{C}$)	Density (g cm^{-3})
Magnesium	650	1.74
Magnesium chloride	714	2.32

When molten magnesium chloride is electrolysed at 730°C the magnesium appears as a

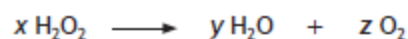
- A solid on the surface of the molten magnesium chloride
- B solid at the bottom of the molten magnesium chloride
- C liquid at the bottom of the molten magnesium chloride
- D liquid on the surface of the molten magnesium chloride.

38.

Which of the following compounds is a base?

- A Sodium carbonate
- B Sodium chloride
- C Sodium nitrate
- D Sodium sulfate

39.



This equation will be balanced when

- A $x = 1$, $y = 2$ and $z = 2$
- B $x = 1$, $y = 1$ and $z = 2$
- C $x = 2$, $y = 2$ and $z = 1$
- D $x = 2$, $y = 2$ and $z = 2$.

40.

0.25 moles of a gas has a mass of 7 g.

Which of the following could be the molecular formula for the gas?

- A C_2H_6
- B C_2H_4
- C C_3H_8
- D C_3H_6

41.

Which of the following solutions contains the least number of moles of solute?

- A 100 cm^3 of 0.4 mol l^{-1} solution
- B 200 cm^3 of 0.3 mol l^{-1} solution
- C 300 cm^3 of 1.0 mol l^{-1} solution
- D 400 cm^3 of 0.5 mol l^{-1} solution

42.

A reaction is exothermic if

- A energy is absorbed from the surroundings
- B energy is released to the surroundings
- C energy is required to start the reaction
- D there is no energy change.

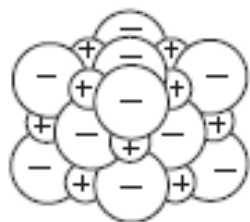
43.

Which of the following diagrams could be used to represent the structure of copper?

A



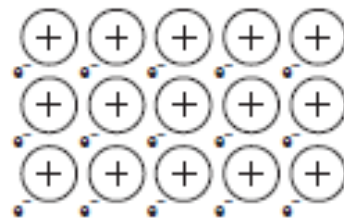
B



C



D



44.

Which of the following elements exists as a covalent network?

- A Helium
- B Nitrogen
- C Silicon
- D Sulfur

45.

Which line in the table correctly describes an electron?

	<i>Mass</i>	<i>Charge</i>
A	negligible	+1
B	negligible	-1
C	1	+1
D	1	0

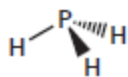
46.

Solid ionic compounds do not conduct electricity because

- A the ions are not free to move
- B the electrons are not free to move
- C solid substances never conduct electricity
- D there are no charged particles in ionic compounds.

47.

A molecule of phosphine is shown below.



The shape of a molecule of phosphine is

- A linear
- B angular
- C tetrahedral
- D trigonal pyramidal.

48. Questions 49 and 50 refer to the table below

Particle	Number of		
	protons	neutrons	electrons
A	9	10	10
B	11	12	11
C	15	16	15
D	19	20	18

Identify the particle which is a negative ion.

49.

Identify the particle which would give a lilac flame colour.

You may wish to use the data booklet to help you.

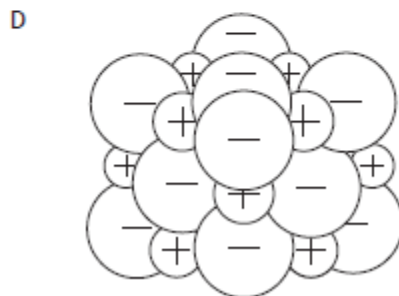
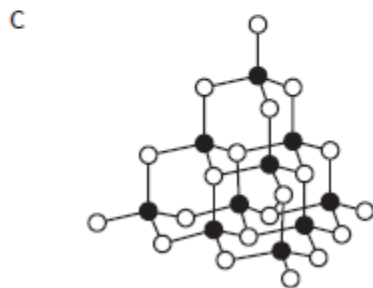
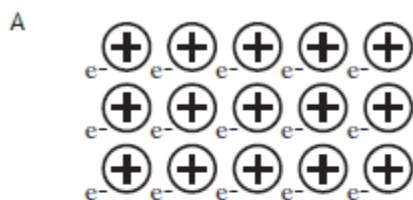
50.

Which of the following statements correctly describes the concentrations of $\text{H}^+(\text{aq})$ and $\text{OH}^-(\text{aq})$ ions in pure water?

- A The concentrations of $\text{H}^+(\text{aq})$ and $\text{OH}^-(\text{aq})$ ions are equal.
- B The concentrations of $\text{H}^+(\text{aq})$ and $\text{OH}^-(\text{aq})$ ions are zero.
- C The concentration of $\text{H}^+(\text{aq})$ ions is greater than the concentration of $\text{OH}^-(\text{aq})$ ions.
- D The concentration of $\text{H}^+(\text{aq})$ ions is less than the concentration of $\text{OH}^-(\text{aq})$ ions.

51.

Which of the following diagrams could be used to represent the structure of a metal?



52.

Which of the following metals does not react with dilute acid?

- A Magnesium
- B Calcium
- C Copper
- D Zinc

53.

The table shows the colours of some ionic compounds in solution.

<i>Compound</i>	<i>Colour</i>
copper nitrate	blue
copper chromate	green
strontium nitrate	colourless
strontium chromate	yellow

The colour of the chromate ion is

- A blue
- B green
- C colourless
- D yellow.

54.

Which of the following substances does not produce water when it reacts with dilute acid?

- A Sodium hydroxide
- B Magnesium
- C Copper oxide
- D Ammonia solution

55.

Hydrogen gas

- A burns with a pop
- B relights a glowing splint
- C turns damp pH paper red
- D turns limewater cloudy.

56.

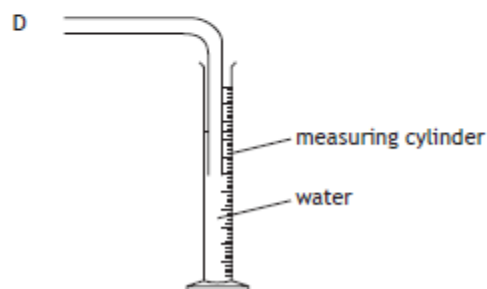
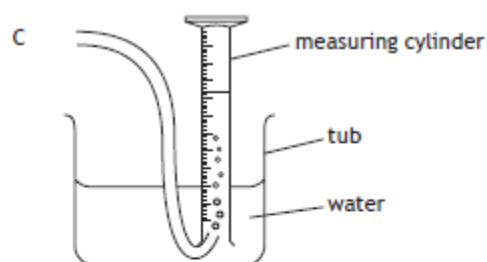
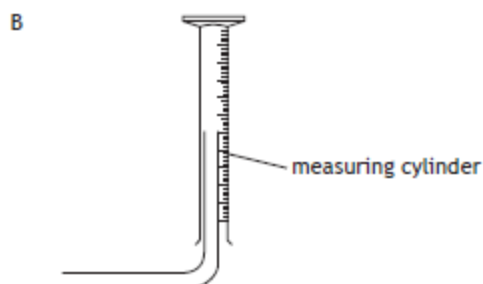
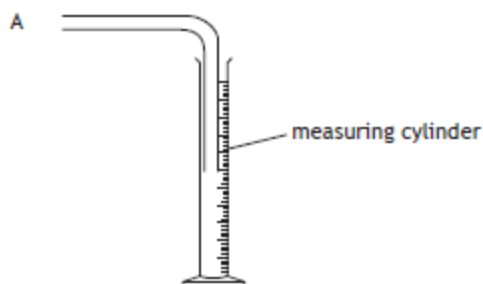
What is the charge on an iron ion in $\text{Fe}_2(\text{SO}_4)_3$?

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

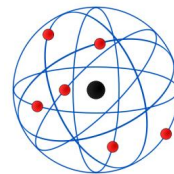
57.

But-1-ene is a colourless, insoluble gas which is more dense than air but less dense than water.

Which of the following diagrams shows the most appropriate apparatus for collecting and measuring the volume of but-1-ene?



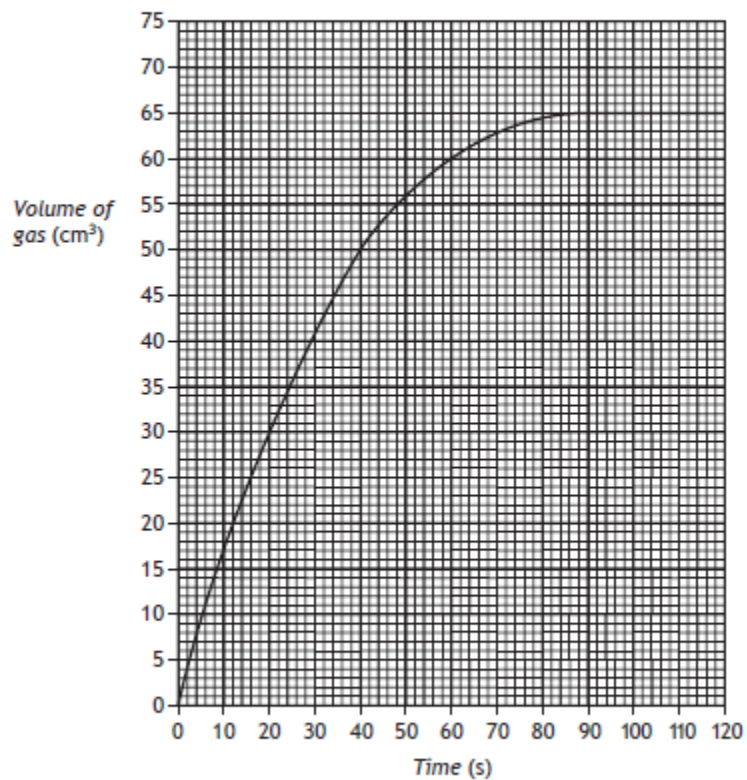
Unit 1 – Chemical Changes and Structure



Section 2

1. Graphs can be used to show the change in the rate of a reaction as the reaction proceeds.

The graph shows the volume of gas produced in an experiment over a period of time.



- (a) State the time, in seconds, at which the reaction stopped.

1

1. (continued)

- (b) Calculate the average rate of reaction for the first 20 seconds. 3

Your answer must include the appropriate unit.

Show your working clearly.

- (c) The graph shows that the rate of reaction decreases as the reaction proceeds.

Suggest a reason for this decrease. 1

2. The group 7 element bromine was discovered by Balard in 1826.
Bromine gets its name from the Greek "bromos" meaning stench.

A sample of bromine consists of a mixture of two isotopes, $^{79}_{35}\text{Br}$ and $^{81}_{35}\text{Br}$.

- (a) State what is meant by the term isotope. 1

- (b) Complete the table for $^{79}_{35}\text{Br}$. 1

Isotope	Number of protons	Number of neutrons
$^{79}_{35}\text{Br}$		

- (c) The sample of bromine has an average atomic mass of 80.
Suggest what this indicates about the amount of each isotope in this sample. 1

3. Antacid tablets are used to treat indigestion which is caused by excess acid in the stomach.

Different brands of tablets contain different active ingredients.

<i>Name of active ingredient</i>	magnesium carbonate	calcium carbonate	magnesium hydroxide	aluminium hydroxide
<i>Reaction with acid</i>	fizzes	fizzes	does not fizz	does not fizz
<i>Cost per gram (pence)</i>	16	11	7.5	22
<i>Mass of solid needed to neutralise 20 cm³ of acid (g)</i>	0.7	1.2	0.6	0.4
<i>Cost of neutralising 20 cm³ of acid (pence)</i>		13.2	4.5	8.8

- (a) Write the formula, showing the charge on each ion, for aluminium hydroxide. 1
- (b) (i) Complete the table to show the cost of using magnesium carbonate to neutralise 20 cm³ of acid. 1
- (ii) Using information from the table, state which one of the four active ingredients you would use to neutralise excess stomach acid. Explain your choice. 1

4. Sulfur dioxide gas is produced when fossil fuels containing sulfur are burned.

- (a) When sulfur dioxide dissolves in water in the atmosphere "acid rain" is produced.

Circle the correct phrase to complete the sentence.

1

Compared with pure water, acid rain contains $\left\{ \begin{array}{l} \text{a higher} \\ \text{a lower} \\ \text{the same} \end{array} \right\}$ concentration of hydrogen ions.

- (b) The table gives information about the solubility of sulfur dioxide.

Temperature (°C)	18	24	30	36	42	48
Solubility (g/100 cm ³)	11.2	9.2	7.8	6.5	5.5	4.7

- (i) Draw a graph of solubility against temperature.

Use appropriate scales to fill most of the graph paper.

4

4. (b) (continued)

- (ii) Estimate the solubility of sulfur dioxide, in g/100 cm³, at 21 °C.

1

5. A student investigated the reaction of carbonates with dilute hydrochloric acid.

- (a) In one reaction lithium carbonate reacted with dilute hydrochloric acid.

The equation for the reaction is:



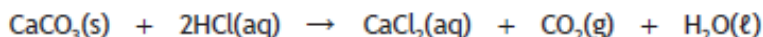
- (i) Balance this equation.

1

- (ii) Identify the salt produced in this reaction.

1

- (b) In another reaction 1.0 g of calcium carbonate reacted with excess dilute hydrochloric acid.



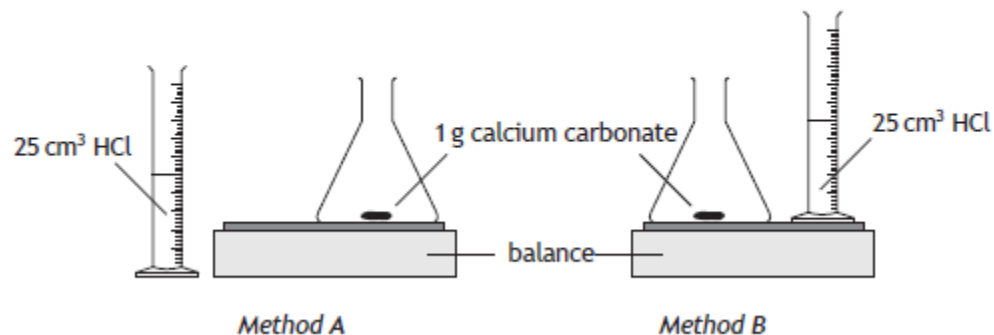
- (i) Calculate the mass, in grams, of carbon dioxide produced.

3

Show your working clearly.

5. (b) (continued)

- (ii) The student considered two methods to confirm the mass of carbon dioxide gas produced in this reaction.



6.

Natural gas, which is mainly methane, was used to fuel the flame in the Olympic cauldron.

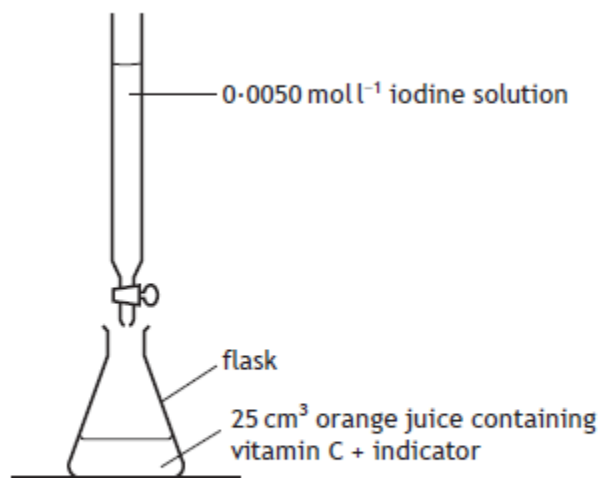
- (i) Draw a diagram to show how all the outer electrons are arranged in a molecule of methane, CH₄.

1

7.

Vitamin C is found in fruits and vegetables.

MARKS



Using iodine solution, a student carried out experiments to determine the concentration of vitamin C in orange juice.

The results of the experiments are shown.

Experiment	Initial volume of iodine solution (cm ³)	Final volume of iodine solution (cm ³)	Volume of iodine solution added (cm ³)
1	1.2	18.0	16.8
2	18.0	33.9	15.9
3	0.5	16.6	16.1

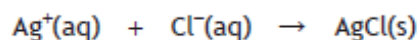
- (a) (i) Name the piece of apparatus used to measure the volume of iodine solution added to the orange juice. 1
- (ii) Calculate the average volume, in cm³, of iodine solution that should be used in calculating the concentration of vitamin C. 1
- (b) Name the experimental method, carried out by the student, to accurately determine the concentration of vitamin C in the orange juice. 1

8.

The concentration of chloride ions in water affects the ability of some plants to grow.

A student investigated the concentration of chloride ions in the water at various points along the river Tay.

The concentration of chloride ions in water can be determined by reacting the chloride ions with silver ions.

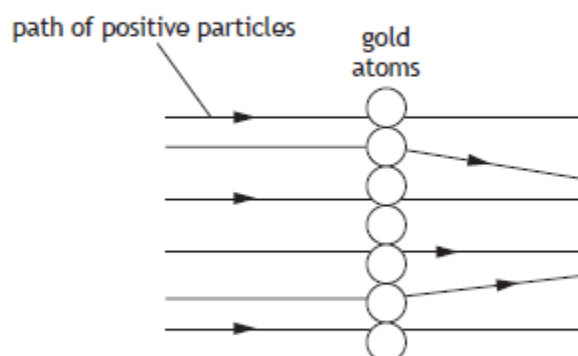


A 20 cm³ water sample gave a precipitate of silver chloride with a mass of 1.435 g.

- (a) Calculate the number of moles of silver chloride, AgCl, present in this sample. 2
- (b) Using your answer to part (a), calculate the concentration, in mol l⁻¹, of chloride ions in this sample. 2

9.

In 1911, Ernest Rutherford carried out an experiment to confirm the structure of the atom. In this experiment, he fired positive particles at a very thin layer of gold foil. Most of the particles passed straight through but a small number of the positively charged particles were deflected.



- (a) What caused some of the positive particles to be deflected in this experiment?

1

- (b) Gold is the heaviest element to have only one naturally occurring isotope.

The isotope has a mass number of 197.

- (i) Complete the table to show the number of each type of particle in this gold atom.

1

You may wish to use the data booklet to help you.

Particle	Number
Proton	
Electron	
Neutron	

- (ii) Most elements have more than one isotope.

State what is meant by the term isotope.

1

10.

- (a) The properties of a substance depend on its type of bonding and structure. There are four types of bonding and structure.

Discrete covalent molecular	Covalent network	Ionic lattice	Metallic lattice
-----------------------------	------------------	---------------	------------------

Complete the table to match up each type of bonding and structure with its properties.

Type of bonding and structure	Properties
	do not conduct electricity and have high melting points
	have high melting points and conduct electricity when liquid but not when solid
	conduct electricity when solid and have a wide range of melting points
	do not conduct electricity and have low melting points

2

- (b) Graphene is a substance made of a single layer of carbon atoms.



Graphene can conduct electricity.

Suggest what this indicates about some of the electrons in graphene.

1

11.

Read the passage below and answer the questions that follow.

Potassium - The Super Element

Potassium is an essential element for almost all living things. The human body requires a regular intake of potassium because humans have no mechanism for storing it. Foods rich in potassium include raisins and almonds. Raisins contain 0.86 g of potassium in every 100 g.

Naturally occurring salts of potassium such as saltpetre (potassium nitrate) and potash (potassium carbonate) have been known for centuries. Potassium salts are used as fertilisers.

Potassium was first isolated by Humphry Davy in 1807. Davy observed that when potassium was added to water it formed globules which skimmed about on the surface, burning with a coloured flame and forming an alkaline solution.

- (a) State why the human body requires a regular intake of potassium. 1
- (b) Calculate the number of moles of potassium in 100 g of raisins. 2
Show your working clearly.
- (c) State the colour of the flame which would be seen when potassium burns. 1
You may wish to use the data booklet to help you.
- (d) Write the ionic formula for saltpetre. 1

12.

Nonane burns to produce carbon dioxide and water.

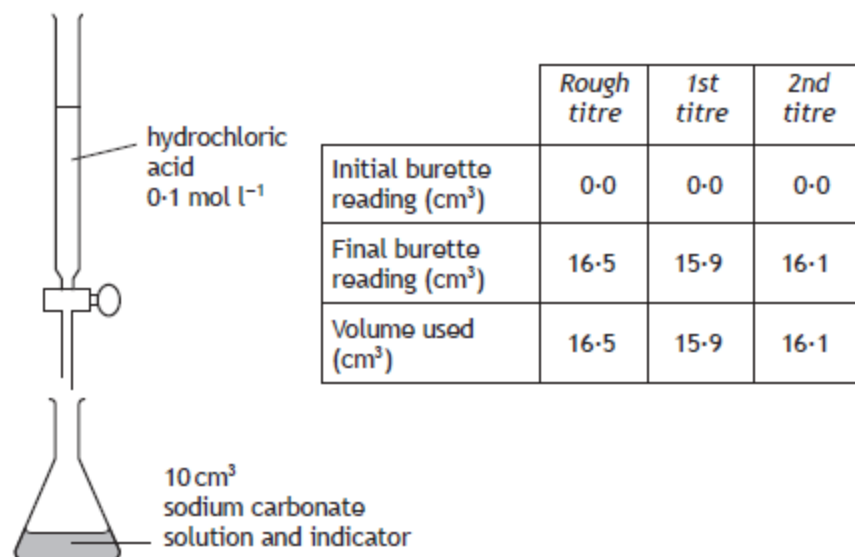


Calculate the mass, in grams, of carbon dioxide produced when 32 g of nonane is burned. 3

Show your working clearly.

13. Sodium carbonate solution can be added to the water in swimming pools to neutralise the acidic effects of chlorine.

A student carried out a titration experiment to determine the concentration of a sodium carbonate solution.



- (a) Using the results in the table, calculate the average volume, in cm³, of hydrochloric acid required to neutralise the sodium carbonate solution. 1

- (b) The equation for the reaction is



Using your answer from part (a) calculate the concentration, in mol l⁻¹, of the sodium carbonate solution. 3

Show your working clearly.

14.

Ethyne is the first member of the alkyne family.

It can be produced by the reaction of calcium carbide with water.

The equation for this reaction is



- (a) The table shows the results obtained in an experiment carried out to measure the volume of ethyne gas produced.

Time (s)	0	30	60	90	120	150	180	210
Volume of ethyne (cm ³)	0	60	96	120	140	148	152	152

Calculate the average rate of reaction between 60 and 90 seconds.

Your answer must include the appropriate unit. 3

Show your working clearly.

15.

Some sources of methane gas contain hydrogen sulfide, H_2S .

- (a) Draw a diagram, showing all outer electrons, to represent a molecule of hydrogen sulfide, H_2S . 1

- (b) If hydrogen sulfide is not removed before methane gas is burned, sulfur dioxide is formed.

When sulfur dioxide dissolves in water in the atmosphere, acid rain is produced.

Circle the correct words to complete the sentence.

Acid rain contains more $\left\{ \begin{array}{c} \text{hydrogen} \\ \text{hydroxide} \end{array} \right\}$ ions than $\left\{ \begin{array}{c} \text{hydrogen} \\ \text{hydroxide} \end{array} \right\}$ ions. 1

- (c) In industry, calcium oxide is reacted with sulfur dioxide to reduce the volume of sulfur dioxide released into the atmosphere.

Explain why calcium oxide is able to reduce the volume of sulfur dioxide gas released. 2

16.

Read the passage below and answer the questions that follow.

Clean coal technology comes a step closer

It is claimed a process called Coal-Direct Chemical Looping (CDCL) is able to release energy from coal while capturing 99% of the carbon dioxide emitted. CDCL works by extracting the energy from coal using a reaction other than combustion.

A mixture of powdered coal and beads of iron(III) oxide is heated inside a metal cylinder. Carbon in the coal and oxygen from the beads react to form carbon dioxide which can be captured for recycling or stored.

This reaction gives off heat energy that could be used to heat water in order to drive electricity-producing steam turbines.

Adapted from *Focus: Science and Technology*, April 2013

- (a) The CDCL process produced 300 tonnes of carbon dioxide.

Calculate the mass, in tonnes, of carbon dioxide released into the atmosphere. 1

- (b) Write the ionic formula for the iron compound used in CDCL. 1

- (c) State the term used to describe all chemical reactions that release heat energy. 1

17.

A student was asked to carry out an experiment to determine the concentration of a copper(II) sulfate solution.

Part of the work card used is shown.

Determination of the Concentration of Copper(II) Sulfate Solution

1. Weigh an empty crucible
2. Add 100 cm³ copper(II) sulfate solution
3. Evaporate the solution to dryness
4. Weigh the crucible containing dry copper(II) sulfate

(a) Suggest how the student could have evaporated the solution to dryness. 1

(b) The student found that the 100 cm³ solution contained 3.19 g of copper(II) sulfate, CuSO₄.

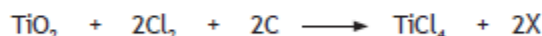
Calculate the concentration of the solution in mol l⁻¹. 2

Show your working clearly.

18.

Titanium is the tenth most commonly occurring element in the Earth's crust.

(a) The first step in the extraction of titanium from impure titanium oxide involves the conversion of titanium oxide into titanium(IV) chloride.



(i) Identify X. 1

(ii) Titanium(IV) chloride is a liquid at room temperature and does not conduct electricity.

Suggest the type of bonding that is present in titanium(IV) chloride. 1

(b) The next step involves separating pure titanium(IV) chloride from other liquid impurities that are also produced during the first step.

Suggest a name for this process. 1

(c) The equation for the final step in the extraction of titanium is



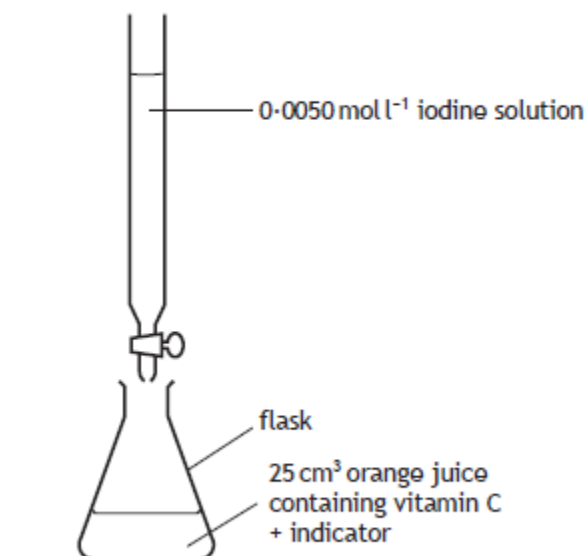
The sodium chloride produced can be electrolysed.

Suggest how this could make the extraction of titanium from titanium oxide more economical. 1

19.

Vitamin C is found in fruits and vegetables.

Using iodine solution, a student carried out titrations to determine the concentration of vitamin C in orange juice.



The results of the titration are given in the table.

<i>Titration</i>	<i>Initial burette reading (cm³)</i>	<i>Final burette reading (cm³)</i>	<i>Titre (cm³)</i>
1	1.2	18.0	16.8
2	18.0	33.9	15.9
3	0.5	16.6	16.1

- (a) Calculate the average volume, in cm³, that should be used in calculating the concentration of vitamin C.

1

- (b) The equation for the reaction is

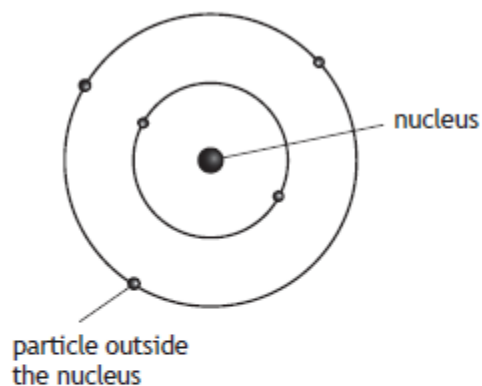


Calculate the concentration, in mol l⁻¹, of vitamin C in the orange juice. 3

Show your working clearly.

20.

Elements are made up of atoms.



(a) Complete the tables to show the missing information.

(i)

In the Nucleus			1
Particle	Relative Mass	Charge	
proton		+1	
neutron	1		

(ii)

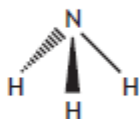
Outside the Nucleus			1
Particle	Relative Mass	Charge	
	almost zero		

(b) A sample of nitrogen was found to contain equal amounts of two isotopes. One isotope has mass number 14 and the other has mass number 15.

What is the relative atomic mass of this sample of nitrogen? 1

(c) Nitrogen can form bonds with other elements.

The diagram shows the shape of a molecule of ammonia (NH_3).



(i) State the name used to describe the shape of a molecule of ammonia. 1

(ii) Name the industrial process used to manufacture ammonia. 1

21.

Hydrogen gas can be produced in the laboratory by adding a metal to dilute acid. Heat energy is also produced in the reaction.

- (a) State the term used to describe all chemical reactions that release heat energy.

1

- (b) A student measured the volume of hydrogen gas produced when zinc lumps were added to dilute hydrochloric acid.

Time (s)	0	10	20	30	40	50	60	70
Volume of hydrogen (cm ³)	0	12	21	29	34	36	37	37

- (i) Calculate the average rate of reaction, in cm³s⁻¹, between 10 and 30 seconds.

2

Show your working clearly.

- (ii) Estimate the time taken, in seconds, for the reaction to finish.

1

- (iii) The student repeated the experiment using the same mass of zinc.

State the effect on the rate of the reaction if zinc powder was used instead of lumps.

1

- (c) Another student reacted aluminium with dilute nitric acid.



- (i) Circle the formula for the salt in the above equation.

1

- (ii) 1 mole of hydrogen gas has a volume of 24 litres.

Calculate the volume of hydrogen gas, in litres, produced when 0.01 moles of aluminium react with dilute nitric acid.

2

Show your working clearly.

22.

Read the passage and answer the questions that follow.

Gold — a very useful metal

Gold has been associated with wealth since before the first gold coins were minted in Lydia (modern Turkey) about 550 BC. It does not react with water, air, alkalis and almost all acids. Gold only has one naturally occurring isotope with mass 197.

As an element it has many uses in the modern world. 1 gram of gold can be beaten into a gold film covering one square metre and thin coatings of gold are used as lubricants in aerospace applications. Gold electroplating can be used to coat electrical connectors and printed circuit boards.

Chemists have recently discovered that gold nanoparticles make superb catalysts for many reactions such as the conversion of alcohols into aldehydes and ketones. It can also be used as a catalyst for removing trace carbon monoxide from gases. In this reaction carbon monoxide reacts with oxygen to form carbon dioxide.

Gold nanorods can be grown from a dilute solution of auric acid and are used in the treatment of some forms of cancer.

Adapted from *Education in Chemistry*, Volume 45, November 2008

(a) Suggest a reason why gold was used in the first coins minted. 1

(b) Calculate the number of neutrons present in the naturally occurring isotope of gold. 1

You may wish to use the data booklet to help you.

(c) (i) Write an equation, using symbols and formulae, to show the reaction for removing trace carbon monoxide from gases. 1
There is no need to balance this equation.

(ii) State the role of gold in this reaction. 1

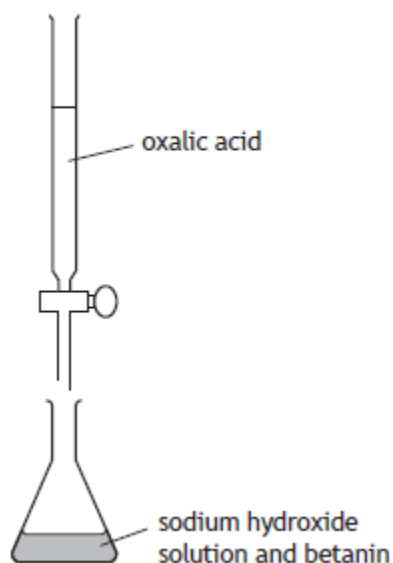
(d) Circle the correct words to complete the sentence. 1

Gold nanorods can be grown from a solution which contains

more $\left\{ \begin{array}{c} \text{hydroxide} \\ \text{hydrogen} \end{array} \right\}$ ions than $\left\{ \begin{array}{c} \text{hydroxide} \\ \text{hydrogen} \end{array} \right\}$ ions.

23.

A student carried out a titration experiment to determine the concentration of a sodium hydroxide solution.



	<i>Initial burette reading (cm³)</i>	<i>Final burette reading (cm³)</i>	<i>Volume used (cm³)</i>
Rough titre	0.0	15.6	15.6
1st titre	15.6	30.5	14.9
2nd titre	30.5	45.6	15.1

Using the results in the table, calculate the average volume, in cm³, of oxalic acid required to neutralise the sodium hydroxide solution.

1

Oxalic acid is found naturally in rhubarb. A piece of rhubarb was found to contain 1.8 g of oxalic acid.

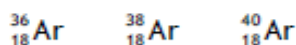
Calculate the number of moles of oxalic acid contained in the piece of rhubarb.

1

(Formula mass of oxalic acid = 90)

24.

A sample of argon contains three types of atom.



(a) State the term used to describe these different types of argon atom.

1

(b) Explain why the mass number of each type of atom is different. 1

(c) This sample of argon has an average atomic mass of 36.2.
State the mass number of the most common type of atom in the sample of argon. 1

25.

Read the passage below and attempt the questions that follow.

Hydrogen Storage

The portable storage of hydrogen (H_2) is key to the development of hydrogen fuel cell cars. While many chemists focus their attention on the use of metal alloys and hydrides for storing hydrogen, others have investigated the potential use of carbon nanotubes.

A carbon nanotube is a tiny rolled up sheet of graphite. A research team has designed a pillared structure made up of vertical columns of carbon nanotubes which stabilise parallel graphene sheets. Graphene sheets are layers of carbon which are one atom thick.

Lithium atoms are added to the pillared structure to increase the hydrogen storage capacity. Researchers claim that one litre of the structure can store 41 g of hydrogen gas, which comes close to the US Department of Energy's target of 45 g.

Adapted from *InfoChem Magazine* (RSC), Nov 2008

(a) Name the term used to describe a tiny rolled up sheet of graphite. 1

(b) Name the metal added to the pillared structure to increase the hydrogen storage capacity. 1

(c) Calculate the number of moles of hydrogen that, researchers claim, can be stored by one litre of this structure. 2
Show your working clearly.

26.

Chlorine can form covalent and ionic bonds.

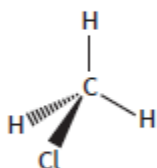
- (a) Chlorine gas is made up of diatomic molecules.

Draw a diagram, showing all outer electrons, to represent a molecule of chlorine, Cl_2 .

1

- (b) Chloromethane is a covalent gas with a faint sweet odour.

The structure of a chloromethane molecule is shown.



State the name used to describe the shape of a molecule of chloromethane.

1

- (c) When chlorine reacts with sodium the ionic compound sodium chloride is formed.

A chloride ion has a stable electron arrangement.

Describe how a chlorine atom achieves this stable electron arrangement.

1

- (d) Covalent and ionic compounds have different physical properties.

Complete the table by circling the words which correctly describe the properties of the two compounds.

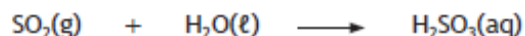
2

<i>Compound</i>	<i>Melting point</i>	<i>Conductor of electricity</i>
chloromethane gas	high / low	yes / no
solid sodium chloride	high / low	yes / no

27.

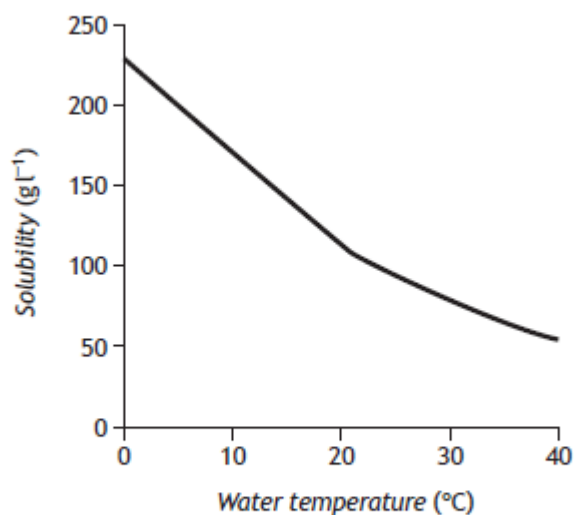
Sulfur dioxide is an important industrial chemical.

Sulfur dioxide dissolves in water to produce sulfurous acid.



(a) Explain the change in the pH of the solution as sulfur dioxide dissolves. 2

(b) The graph shows the solubility of sulfur dioxide at different temperatures.



Describe the general trend in solubility as the temperature of the water increases.

1

28.

A student prepared a sample of geranyl propanoate from geraniol and propanoic acid.



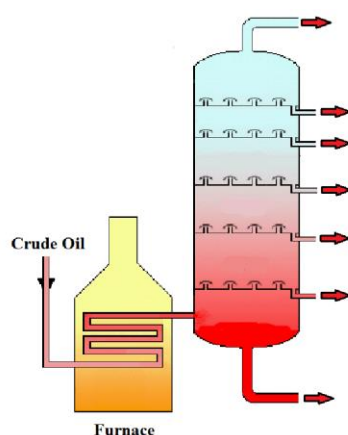
15.4 g of geraniol was reacted with excess propanoic acid.

Calculate the mass, in grams, of geranyl propanoate which would be produced.

3

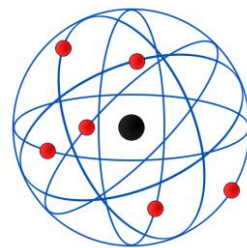
Show your working clearly.

Unit 1 Past Paper Answers



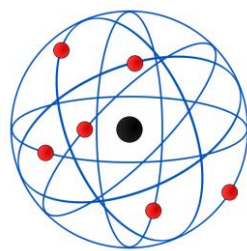
																		He									
																		Ne									
																		Ar									
																		Kr									
																		Xe									
																		Rn									

Section 1 Answers



1	A	11	A	21	B	31	A	41	A	51	A
2	D	12	B	22	C	32	C	42	B	52	C
3	A	13	D	23	A	33	B	43	D	53	D
4	C	14	C	24	D	34	D	44	C	54	B
5	C	15	D	25	D	35	C	45	B	55	A
6	A	16	C	26	D	36	A	46	A	56	B
7	D	17	C	27	C	37	D	47	D	57	C
8	A	18	B	28	D	38	A	48	A		
9	C	19	A	29	B	39	C	49	D		
10	D	20	B	30	C	40	B	50	A		

Section 2 Answers



Question		Expected response	Max mark	Additional guidance
1.	(a)	86–90 (seconds)	1	Units are not required, but 0 marks can be awarded for the correct answer if incorrect unit is given
	(b)	1.5 cm ³ s ⁻¹ (3) Partial marking: 1.5 with no unit/incorrect unit (2) $\frac{30-0}{20-0}$ or $\frac{30}{20}$ or $\frac{0-30}{0-20}$ (1) Correct unit cm ³ s ⁻¹ (1)	3	Accept cm ³ /s Do not accept cm ³ /s ⁻¹
	(c)	Less reactants or concentration of reactants decreases or reactants are used up or less chance of particles colliding or equivalent answer	1	
2.	(a)	Atoms with same atomic number/number of protons/positive particles but different mass number/number of neutrons	1	
	(b)	Protons = 35 Neutrons = 44	1	Both required for 1 mark
	(c)	Equal amounts/proportions/abundance or same number of each or 50:50 or equivalent answers	1	

Question			Expected response	Max mark	Additional guidance
3.	(a)		$Al^{3+}(OH^-)_3$	1	
	(b)	(i)	11.2 (pence)	1	
		(ii)	<p>Named active ingredient with an appropriate reason.</p> <p>e.g. magnesium hydroxide – cheapest / doesn't fizz</p> <p>aluminium hydroxide – need to take least amount</p>	1	

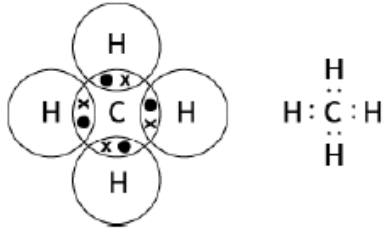
Question			Expected response	Max mark	Additional guidance
4.	(a)		a higher	1	
	(b)	(i)	<p>For appropriate format: scatter graph – ie a graph in which points are plotted with their x and y values representing temperature and solubility (1)</p> <p>The axis/axes of the graph has/have suitable scale(s). For the graph paper provided within the question paper, the selection of suitable scales will result in a graph that occupies at least half of the width and half of the height of the graph paper (1)</p> <p>The axes of the graph have suitable labels and units (1)</p> <p>All data points plotted accurately with a line of best fit drawn (1)</p>	4	<p>Where the candidate has drawn a bar graph the format mark is not awarded, but the remaining three marks can still be accessed.</p> <p>For bar graphs, this mark is awarded for the selection of a suitable scale on the y-axis.</p> <p>Spelling mistakes or the use of abbreviations should not be penalised if the meaning of an axis label may be clearly understood.</p> <p>Where the candidate has drawn a bar graph, the mark for accurate plotting can be awarded if the heights of bars are plotted accurately but in this case no line of best fit is required.</p>

		(ii) 10.2 – 10.3 (g/100 cm ³) or a value correctly read from candidate's graph (allow ½ box tolerance)	1	Units are not required, but 0 marks can be awarded for correct answer if incorrect unit is given.
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Question			Expected response	Max mark	Additional guidance
5.	(a)	(i)	$\text{Li}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{LiCl} + \text{CO}_2 + \text{H}_2\text{O}$	1	Accept correct multiples
		(ii)	LiCl or lithium chloride	1	Accept formula for LiCl circled or highlighted in the equation.
	(b)	(i)	0.44 (g) (3) Partial marking: Both <i>GFM</i> s 100 and 44 (1) Correct application of the relationship between moles and mass (1) This could be shown: <ul style="list-style-type: none"> by working containing the two expressions $\frac{1}{\text{candidate's } GFM \text{ for } \text{CaCO}_3}$ and <i>no. moles</i> $\text{CO}_2 \times \text{candidate's } GFM \text{ CO}_2$ or by working showing correct proportionality $1 \leftrightarrow \frac{\text{candidate } GFM \text{ CO}_2}{\text{candidate } GFM \text{ CaCO}_3}$ Where the candidate has been awarded the mark for the correct application of the relationship between moles and mass, a further mark can be awarded for correct follow through to a final answer. (1)	3	Units are not required, but a maximum of 2 marks can be awarded for the correct answer if incorrect unit is given.

Question		Expected response	Max mark	Additional guidance
	(ii)	Method B (1) gas is lost in method A before starting mass taken or gas is lost before all acid is added or no total mass of all reactants at the start of experiment or equivalent response (1)	2	

6.

(i)	<p>Diagram showing carbon with four hydrogen atoms: each of the four overlap areas must have two electrons in or on overlap area (cross, dot, petal diagram).</p> <p>e.g.</p> 	1	<p>The diagram does not need to show tetrahedral shape</p>
(ii)	<p>weak bond/attraction (1)</p> <p>between molecules (1)</p>	2	

7.

(a)	(i)	burette	1	
	(ii)	16 or 16.0 (cm ³)	1	Units are not required, 0 marks can be awarded for the correct answer if incorrect unit is given.
(b)		titration	1	

8.

(a)		0.01 (mol) (2)	2	Units are not required but a maximum of 1 mark can be awarded for the correct answer if incorrect unit is given.
		Partial marking: 1 mark can be awarded for either <ul style="list-style-type: none"> • 143.5 g or <ul style="list-style-type: none"> • correctly calculated answer for $\frac{1.435}{\text{incorrect GFM}}$ 		

(b)	0.5 (mol l ⁻¹) (2)	2	Units are not required but a maximum of 1 mark can be awarded for the correct answer if incorrect unit is given.
	<p>Partial marking:</p> <p>1 mark can be awarded for either</p> <ul style="list-style-type: none"> • $\frac{0.01}{0.02}$ <p>or</p> <ul style="list-style-type: none"> • correctly calculated answer for $\frac{0.01}{20}$ 		<p>Allow follow through from answer to 15(a)</p> <p>If correct relationship is used but volume not converted to litres eg 0.01/20 maximum 1 mark</p>

9.

(a)		Repulsion/repelled by nucleus/positive nucleus /protons/positive protons/positive particles in nucleus or in atom or in gold/ like charges in nucleus, atom or gold	1	<p>Zero marks for just mentioning positive particles/protons etc in nucleus without mentioning them repelling</p> <p>Zero marks for positive particles or like charges without mentioning it is those in nucleus or atom or gold</p> <p>Zero marks for positive charge of the gold atoms</p>
(b)	(i)	<p>Protons - 79</p> <p>Electrons - 79</p> <p>Neutrons - 118</p> <p>All for 1 mark</p>	1	

(ii)	<p>Same atomic number / protons AND different mass number / mass / number of neutrons</p> <p>Atoms of the same element with different mass number / mass / number of neutrons</p> <p>Candidate must specify either same atomic number or number of protons/positive charges or atoms of the same element AND different mass number/mass/number of neutrons</p>	1	<p>If electrons mentioned this does not negate a correct answer</p> <p>Do not accept Particles, molecules or same atoms with ...</p> <p>Same element with different mass number</p>
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10.

(a)	<p>Covalent network Ionic lattice Metallic lattice (Discrete) covalent molecular</p>	2	<p>All 4 correct - 2 marks</p> <p>2 or 3 correct - 1 mark</p> <p>1 or 0 correct - 0 marks</p>
(b)	<p>Delocalised /able or free to move or correct description</p>	1	<p>Mention of ions negates correct answer</p>

11.

(a)	Potassium is an essential element or humans / human body cannot store it / have no mechanism for storing it	1	
(b)	<p>0.022 or 0.02 (moles) with no working (2)</p> <p>0.86 / 39 = (1)</p> <p>0.022 or 0.02 (moles) (1)</p>	2	<p>Any incorrect answer with no working award zero marks</p> <p>Allow follow through if incorrect value extracted from text and correctly divided by 39.</p> <p>39/0.86 = 45.34 1 mark</p> <p>0.86/100 = 0.0086 1 mark</p> <p>100/39 = 2.56 1 mark</p> <p>Any other response zero marks</p>
(c)	Lilac/purple	1	
(d)	<p>$K^+ NO_3^-$</p> <p>both charges must be shown</p>	1	<p>Also accept use of brackets which do not negate the correct ionic formula e.g.</p> <p>$(K^+) (NO_3^-)$ $(K)^+ (NO_3)^-$</p> <p>$K^+ (NO_3^-)$ $(K^+) NO_3^-$</p> <p>Do not accept $(K)^+ (NO)_3^-$ $K^+ No_3^-$</p> <p>If ionic formula for potash $(K^+)_2 CO_3^{2-}$ is given this negates correct answer unless correct answer is identified by candidate as being saltpetre or potassium nitrate</p>

12.

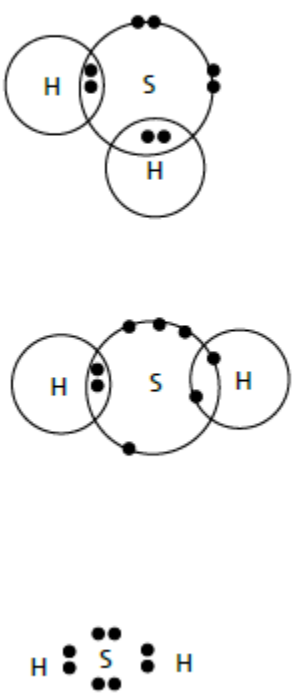
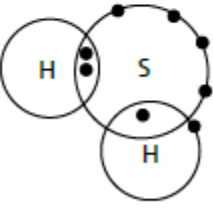
Question	Answer	Max Mark	Additional Guidance
(b)	<p>99 with no working (3)</p> <p>32/128 = 0.25 (1)</p> <p>0.25 gives 2.25 (9 x 0.25) (1) (this step on its own 2 marks)</p> <p>2.25 x 44 = 99 (1) (this step on its own 3 marks)</p> <p>-----</p> <p>-</p> <p>128 g and 44 g both shown (1)</p> <p>128 g gives 396 g (9 x 44) (1) (this step on its own 2 marks)</p> <p>32 g gives 99 g [(396/128) x 32] (1) (this step on its own 3 marks)</p> <p>-----</p> <p>128 g and 44 g both shown (1)</p> <p>128 g gives 396 g (9 x 44) (1) (this step on its own 2 marks)</p> <p>128/32 = 4 396/4 = 99 (1) (this step on its own 3 marks)</p> <p>Any other valid method accepted.</p>	3	<p>32/96 (mass of nonane incorrect) = 0.33 zero marks 0.33 x 9 = 2.97 1 mark correct follow through 2.97 x 44 = 130.68 1 mark correct follow This would be awarded 2 out of 3 marks</p> <p>-----</p> <p>-</p> <p>Any other answer without working = zero marks</p> <p>Unit not required however if wrong unit given do not award mark for final answer.</p> <p>If candidate uses incorrect mass for 9 moles CO₂ and has clearly shown working for this step maximum 2 marks can be awarded.</p> <p>If candidate uses incorrect mass for 9 moles of CO₂ and has shown no working for this step maximum of 1 mark can be awarded.</p> <p>This also applies to GFM of nonane.</p>

Question	Answer	Max Mark	Additional Guidance
13. (a)	16	1	Unit not required however if wrong unit given do not award mark for final answer.
(b)	<p>0.08 with no working 3 marks</p> <p>$0.1 \times 0.016 = 0.0016$ (1)</p> <p>$0.0016/2 = 0.0008$ (1)</p> <p>$0.0008/0.01 = 0.08$ (1)</p> <p>0.08 on its own 3 marks</p> <p>or</p> <p>$\frac{0.1 \times 16}{2} = \frac{C_2 \times 10}{1}$ (1)</p> <p>$0.8 = C_2 \times 10$ (1)</p> <p>$C_2 = 0.08$ (1)</p> <p>or any alternative correct method</p>	3	<p>Allow follow through from part (a)</p> <p>For the first method shown candidates should not be penalised if 16 (or volume from part a) and 10 (volume of sodium carbonate solution) are both expressed in cm^3.</p> <p>If candidate only calculates number of moles of acid the volume must be in litres to be awarded 1 mark.</p> <p>If candidate correctly divides their number of moles of acid by 2 the mark for the mole ratio can be awarded.</p> <p>Unit not required however if wrong unit given do not award mark for final answer. Accept mol l^{-1} or mol/l but not mol/l^{-1} or mol^{-1} or mol l</p> <p>If concentration of incorrect chemical is calculated then max= 1 mark</p>

Question		Answer	Max Mark	Additional Guidance
1.	(a)	<p>0.8 cm³s⁻¹ or 0.8 cm³/s with no working (3)</p> <hr/> <p>For partial marking</p> <p>Maximum 2 marks for calculation.</p> <p>Final mark is awarded for the correct unit.</p> <p>$\frac{120-96}{90-60}$ or $\frac{96-120}{60-90}$ or 24/30 (1)</p> <p>0.8 (1) (this answer without working 2 marks)</p> <p>The mark for the correct unit, cm³s⁻¹ or cm³/s or cubic centimetres per second or cm³ per second, is independent of the other marks. (1)</p>	3	<p>Please note that the unit mark is independent of the other marks.</p> <p>Correct method (i.e. change in volume/change in time) but incorrect arithmetic using correct values from table. 1 mark for calculation</p> <p>Correct method but incorrect values from the table used (subtractions must be shown). 1 mark for calculation</p> <p>If correct method is used but values used are not in the table. 0 marks for calculation</p> <p>If incorrect method used (i.e. change in time/change in volume). 0 marks for calculation</p> <p>Do not accept cm³/s⁻¹ or cm³s⁻¹ or cm3s-1 etc. 's' is the only acceptable abbreviation of second.</p> <p>Refer to General Marking Principle (j) for guidance.</p>

(b)	<p>Both axes labelled with units (1)</p> <p>Both scales (1)</p> <p>Graph drawn accurately (1) (points must be plotted correctly and line drawn, either by joining the dots or by a smooth curve or curve of best fit) The line must be drawn from the origin.</p>	3	<p>Accept volume of ethyne (cm^3), volume of C_2H_2 (cm^3), volume of gas (cm^3), volume (cm^3), as label.</p> <p>Accept 0/0 or a common zero on the axis. The zero does not have to be shown on the scale.</p> <p>Accept time on the x axis and volume on the y axis or vice versa.</p> <p>Allow 1 plotting error. Line not drawn to the origin does not count as a plotting error i.e. if the line is not drawn to the origin a maximum of two marks can be awarded. Allow $\frac{1}{2}$ box tolerance</p> <p>Bar graph maximum 2 marks</p> <p>Max 2 marks if the graph plotted takes up less than half of the graph paper for either axis.</p>
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15.

(a)	<p>Diagram showing two hydrogen atoms and one sulfur atom with two pairs of bonding electrons and two non-bonding pair of electrons in sulfur e.g.</p> 	1	<p>All symbols must be shown.</p> <p>Accept cross or dot or e to represent electrons or a mixture of these.</p> <p>Accept petal diagram for sulfur but not for hydrogen.</p> <p>The non-bonding electrons in sulfur must be shown but do not need to be shown as a pair or be together or be on the line.</p> <p>Bonding electrons MUST be on the line or in the overlapping area. The example below is awarded 0 marks.</p>  <p>If inner electrons on sulfur are shown they must be correct ie 2,8</p>
(b)	<p>1st = hydrogen</p> <p>2nd = hydroxide</p> <p>Both required for 1 mark</p>	1	<p>Accept correct words underlined/highlighted rather than circled.</p>
(c)	<p>It/calcium oxide is a base</p> <p>or</p> <p>forms an alkaline solution (alkali) when dissolved in water. For the mention of alkali the candidate must explicitly state the calcium oxide is in solution/dissolved in water (1)</p> <p>Mention of it neutralising sulfur dioxide/it neutralises it/or a neutralisation reaction takes place. (1)</p>	2	<p>Calcium is a base or alkali is not acceptable for the first mark.</p> <p>The two marks are independent of each other. e.g. a candidate who only states 'it neutralises it' would be awarded 1 mark out of a possible two.</p> <p>A candidate who states that calcium oxide is a base and reacts with sulfur dioxide would be awarded 1 mark out of a possible two.</p>

16.

(a)		3	1	Unit is not required however if the wrong unit is given do not award the mark. 0 marks are awarded for 3.03 Accept abbreviations for unit that convey the meaning.
(b)		$(\text{Fe}^{3+})_2(\text{O}^{2-})_3$ or $\text{Fe}^{3+}_2 \text{O}^{2-}_3$ or $(\text{Fe}^{3+})_2 \text{O}^{2-}_3$ or $\text{Fe}^{3+}_2 (\text{O}^{2-})_3$ or $\text{Fe}_2^{3+} \text{O}_3^{2-}$	1	Refer to General Marking Principle (n) for guidance. Both charges must be shown and correct Award zero marks for Fe_2O_3 $\text{Fe}^{3+}_2\text{O}_3$ $\text{Fe}_2\text{O}^{2-}_3$ $2\text{Fe}^{3+}(\text{O}^{2-})_3$
(c)		Exothermic or exothermal	1	Any mention of endothermic negates the correct answer. Refer General Marking Principle (f) for guidance.

17.

(a)	Boil it or boil off the water or heat it or leave it for some time/overnight/next lesson or leave it on the window ledge or use Bunsen (burner) or appropriate diagram	1	Any mention of filtering negates the correct answer. Refer to General Marking Principle (g) for guidance. Award zero marks for leave it with no indication of appropriate time or do nothing. Award zero marks awarded for mention of burn or burning. This negates the correct answer.
(b)	<div data-bbox="224 615 613 688">0.2 with no working (2)</div> <hr/> <div data-bbox="224 709 613 1150"> <p>Partial marking</p> <p>$3.19/159.5 = 0.02$ (1)</p> <p>$0.02/0.1 = 0.2$ (1) (this step on its own 2 marks)</p> <p>or</p> <p>(3.19 in 100 cm³) 31.9 in 1000 cm³ or 1 litre (1)</p> <p>$31.9/159.5 = 0.2$ (1) (this step on its own 2 marks)</p> </div>	2	<p>Allow follow through from step 1</p> <p>Award 1 mark for 0.1 --> 3.19 1 --> 31.9</p> <p>Zero marks are awarded for only showing $c=n/v$ where the answer is not 0.2</p> <p>Unit is not required however if the wrong unit is given a maximum of 1 mark out of 2 can be awarded.</p> <p>Accept mol l⁻¹ or mol/l ('L' in place of 'l')</p> <p>Do not accept mol/l⁻¹ or mol⁻¹ or mol l</p>

18.

(a)	(i)	Carbon monoxide or CO/2CO	1	Zero marks awarded for Co or cO
	(ii)	Covalent	1	Ignore the mention of single or double bonds. Refer to General Marking Principle (h) for guidance. Accept covalent molecular/ covalent discrete/ covalent discrete molecular. Do not accept molecular on its own. Do not accept covalent network The mention of ionic negates the correct answer. Refer to General Marking Principle (g) for guidance.

(b)		Distillation/distilling	1	Zero marks awarded for fractional on its own, however it does not negate the correct answer. Zero marks awarded for 'evaporation then condensation'.
(c)		The sodium or chlorine or products can be recycled/reused or Chlorine can be used in the first step or Sodium can be used in final step	1	Award zero marks for sodium or chlorine or products could be sold etc. However, this does not negate a correct answer. A statement about recycling or reusing for anything outwith this process on its own should be awarded zero marks but does not negate a correct answer. Any mention of 'will not pollute' etc. is awarded zero marks on its own but does not negate a correct answer. Zero marks awarded for 'it can be recycled' as 'it' refers to sodium chloride.

19.

(a)	16	1	Unit is not required however if the wrong unit is given do not award mark.
(b)	<p>0.0032/3.2 x 10⁻³ with no working or correctly rounded answer (3)</p> <hr/> <p>Partial marking</p> <p>0.0050 x 0.016 = 0.00008 mol I₂ (1)</p> <p>0.00008 mol of Vit C (1) (this step on its own gets 2 marks)</p> <p>0.00008/0.025 = 0.0032/3.2 x 10⁻³ (1) (this step on its own gets 3 marks)</p> <p>or</p> <p>0.0050 x 16 = 0.08 mol I₂ (1)</p> <p>0.08 mol of Vit C (1) (this step on its own gets 2 marks)</p> <p>0.08/25 = 0.0032/3.2 x 10⁻³ (1) (this step on its own gets 3 marks)</p> <p>or</p>	3	<p>Allow follow through from part 15(a). Refer to General Marking Principle (k) for guidance.</p> <p>Candidates should not be penalised if 16 (or volume from part a) and 25 (volume of vitamin C solution) are both expressed in cm³.</p> <p>If candidate expresses one volume in cm³ and the other in litres then a maximum of two marks can be awarded.</p> <p>If candidate only calculates number of moles of iodine the volume must be in litres to be awarded 1 mark i.e. 0.0050 x 16 = 0.08 mol I₂ on its own with no further working is awarded zero marks.</p> <p>Zero marks are awarded if values for C, V and n are given but not used in an appropriate method.</p>
	<p>$\frac{C_1 \times 25}{1} = \frac{0.0050 \times 16}{1}$ (1) (1)</p> <p>C₁ x 25 = 0.08 (this step on its own gets 2 marks)</p> <p>C₁ = 0.0032/3.2 x 10⁻³ (1) (this step on its own gets 3 marks)</p> <p>or</p> <p>$\frac{C_1 \times 0.025}{1} = \frac{0.0050 \times 0.016}{1}$ (1) (1)</p> <p>C₁ x 0.025 = 0.00008 (this step on its own gets 2 marks)</p> <p>C₁ = 0.0032/3.2 x 10⁻³ (1) (this step on its own gets 3 marks)</p> <p>OR ANY OTHER ACCEPTABLE METHOD</p>		<p>For method using relationship shown in the data book 1 mark is awarded for the correct pairings of volume (in the same unit) and concentration.</p> <p>1 mark is awarded for the correct mole ratio being applied.</p> <p>1 mark is awarded for the correct arithmetic. This mark can only be awarded if an appropriate method has been used.</p> <p>Unit is not required however if the wrong unit is given then the final mark cannot be awarded.</p> <p>Accept mol l⁻¹ or mol/l but not mol/l⁻¹ or mol⁻¹ or mol l</p>

(a)	(i)	<table><tr><th colspan="3">In the Nucleus</th></tr><tr><th>Particle</th><th>Relative Mass</th><th>Charge</th></tr><tr><td>Proton</td><td>1</td><td></td></tr><tr><td>Neutron</td><td></td><td>0 neutral no charge</td></tr></table> <p>BOTH REQUIRED</p>	In the Nucleus			Particle	Relative Mass	Charge	Proton	1		Neutron		0 neutral no charge	1	
In the Nucleus																
Particle	Relative Mass	Charge														
Proton	1															
Neutron		0 neutral no charge														
	(ii)	<table><tr><th colspan="3">Outside the Nucleus</th></tr><tr><th>Particle</th><th>Relative Mass</th><th>Charge</th></tr><tr><td>ELECTRON</td><td></td><td>- -1 negative</td></tr></table> <p>BOTH REQUIRED</p>	Outside the Nucleus			Particle	Relative Mass	Charge	ELECTRON		- -1 negative	1				
Outside the Nucleus																
Particle	Relative Mass	Charge														
ELECTRON		- -1 negative														
(b)		14.5	1	Accept 14.5 g or 14.5 amu.												

(c)	(i)	Pyramidal OR Trigonal pyramidal	1	Zero marks awarded for trigonal on its own. Zero marks awarded for 'pyramid'.
	(ii)	Haber	1	

21.

(a)		Exothermic OR exothermal	1	Zero marks awarded for 'combustion'. This also negates a correct answer.
(b)	(i)	<p>0.85 with no working 2 marks</p> <hr/> <div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center;"> $\frac{29-12}{30-10} \quad \text{or} \quad \frac{12-29}{10-30}$ <p>OR</p> $17/20$ </div> <div style="font-size: 3em; margin: 0 10px;">}</div> <div style="text-align: center;"> <p>(1)</p> <p>0.85</p> <p>(1)</p> </div> </div>	2	<p>1 mark awarded for – correct method (ie change in volume/change in time) but incorrect arithmetic using correct values from table.</p> <p>1 mark awarded for – correct method but incorrect values from the table used (subtractions must be shown and volumes chosen must correspond to chosen times).</p> <p>Award zero marks awarded if correct method is used but values are not in the table.</p> <p>Unit is not required however if the wrong unit is given do not award second mark.</p> <p>Acceptable units are $\text{cm}^3 \text{s}^{-1}$ or cm^3/s or cubic centimetres per second or cm^3 per second.</p> <p>Do not accept $\text{cm}^3/\text{s}^{-1}$ or $\text{cm}^3 \text{s}^{-1}$ or $\text{cm}^3 \text{s}^{-1}$ etc. 's' is the only acceptable abbreviation of second.</p>
(ii)		Any value greater than 50 and less than or equal to 60.	1	<p>Zero marks awarded if correct answer given with incorrect unit of time (eg minutes).</p> <p>'s' is the only acceptable abbreviation of second.</p>

(b)	(iii)	Faster / quicker / increase / speed up	1	<p>Zero marks awarded for less time, but does not negate.</p> <p>Zero marks awarded for "fast" reaction without comparison.</p> <p>Incorrect explanation negates eg the reaction speeds up due to increase in particle size.</p>
(c)	(i)	$\text{Al}(\text{NO}_3)_3$ circled, underlined etc	1	

(ii)	0.36 with no working	2	<p>If correct mole ratio (2:3) applied and answer of 36 eg 1.5×24 given award max 1 mark (working must be shown).</p>
	<p>0.01 moles gives 0.015 moles (1)</p> <p>$0.015 \times 24 = 0.36$ (1)</p> <p>This step on its own 2 marks</p>		<p>If candidate shows mass of aluminium accept 54g to 72l or 27g to 36l for 1 mark</p> <p>Zero marks awarded for $0.01 \times 24 = 0.24$</p> <p>Unit is not required however if the wrong unit is given do not award final mark.</p>

22.

(a)	Unreactive OR does not react with water/air/alkalis/ (almost all) acids OR Can be beaten into shape OR Found uncombined	1	Zero marks awarded for phrases like "associated with wealth" on their own but do not negate correct answer. Zero marks awarded for soft on its own but does not negate.
(b)	118	1	
(c) (i)	$\text{CO} + \text{O}_2 \longrightarrow \text{CO}_2$ <p>ALL CORRECT FOR 1 MARK</p> <p>OR</p> $\text{CO} + \text{O}_2 \xrightarrow{\text{Au}} \text{CO}_2$	1	If equation is balanced then it needs to be correct eg $2\text{CO} + \text{O}_2 \longrightarrow 2\text{CO}_2$ $\text{CO} + \frac{1}{2}\text{O}_2 \longrightarrow \text{CO}_2$ Zero marks awarded for $\text{CO} + \text{O}_2 = \text{CO}_2$ $\text{CO} + \text{O}_2 + \text{Au} \longrightarrow \text{CO}_2 + \text{Au}$ State symbols should be ignored. Zero marks awarded for a word equation on its own but this does not negate a correct formulae equation.
(ii)	Catalyst OR catalysis OR speeds up the reaction OR allows less energy/heat to be used for the reaction OR lowers activation energy	1	Zero marks awarded for spectator ion and this negates correct answer.
(d)	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; border-radius: 50%; padding: 5px; text-align: center;">hydroxide hydrogen</div> <div style="border: 1px solid black; border-radius: 50%; padding: 5px; text-align: center;">hydroxide hydrogen</div> </div> <p>BOTH REQUIRED</p>	1	

23.

(c)		15.0	1	Unit is not required however if the wrong unit is given do not award mark. If more than two numbers have been averaged the mark cannot be awarded even if the candidate has the correct answer.
(d)		0.02	1	Zero marks awarded for 0.02 mol ⁻¹ or 0.02 mol l ⁻¹ etc.

24.

(a)		Isotope(s)	1	
(b)		Different numbers of neutrons or the atoms have 18, 20 or 22 neutrons	1	Award zero marks for -different mass in the nucleus -different number of particles in the nucleus
(c)		36 or $^{36}_{18}\text{Ar}$ or ^{36}Ar	1	Accept amu or g if stated.

25.

(a)	Carbon nanotube or Nanotube	1	Award zero marks for -carbon on its own -graphene nanotubes -graphite nanotubes
(b)	Lithium or Li	1	
(c)	<p>20.5 with no working (2)</p> <p>21 with correct working (2)</p> <p>Partial marking Demonstration of the correct use of the relationship concept. ie $41/2$. (1)</p> <p>or</p> <p>$41/1 = 41$ (1) Working must be shown</p>	2	<p>Accept mol l^{-1} or mol/l</p> <p>Zero marks awarded for - 41 without working.</p>

26.

(c)	<p>Gains an electron (from sodium)</p> <p>or</p> <p>Indication that the electron arrangement increases by 1 eg electron arrangement goes from 2.8.7 to 2.8.8, outer electron number goes from 7 to 8.</p>	1	<p>Accept</p> <ul style="list-style-type: none"> - sodium gives an electron - chlorine takes an electron <p>Award zero marks for</p> <ul style="list-style-type: none"> - implying that chlorine gains more than one electron - a chloride ion gains an electron
(d)	<div data-bbox="235 562 548 613" style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">low no 1 mark</div> <div data-bbox="235 651 548 701" style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">high no 1 mark</div> <p>1 mark for both correct properties for chloromethane gas</p> <p>1 mark for both correct properties for solid sodium chloride</p>	2	

27.

(a)	<p>pH of solution goes down / decreases / goes below 7 / goes to a value less than 7 from 7 because the H^+ ion / hydrogen ion concentration increases / goes up or more H^+ than OH^- / $\text{H}^+ > \text{OH}^-$ (2)</p> <hr style="border-top: 1px dashed black;"/> <p>Partial marking</p> <p>pH of solution goes down / decreases / goes below 7 / goes to a value less than 7 from 7 (1)</p> <p>or</p> <p>H^+ ion / hydrogen ion concentration increases / goes up / more H^+ than OH^- / $\text{H}^+ > \text{OH}^-$ (1)</p>	2	<p>Award zero marks for</p> <ul style="list-style-type: none"> - it gets more acidic - sulfur dioxide is a non-metal / acidic oxide <p>These two do not negate a correct answer.</p> <p>Award zero marks for any mention of pH being above 7.</p> <p>If the candidate states the pH increases / goes up / goes above 7, the mark for the description of more H^+ cannot be awarded.</p>
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(b)	Decreases /goes down /gets lower	1	<p>If the candidate mentions temperature and solubility in their answer the cause and effect must be given ie</p> <ul style="list-style-type: none"> - as the temperature increases the solubility decreases or the solubility decreases as the temperature increases <p>Award zero marks for</p> <ul style="list-style-type: none"> - as the solubility decreases the temperature increases or - the temperature increases as the solubility decreases
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28.

(c)	<p>21 (g) (3)</p> <hr/> <p>Partial marks</p> <p>1 mark for either:</p> <p>Both GFM's</p> <p>ie 154 and 210</p> <p>or</p> <p>Moles of geraniol</p> <p>ie $(15.4 / 154) = 0.1 \text{ mol}$</p> <hr/> <p>1 concept mark for either:</p> $15.4 \times \frac{\text{GFM of ester}}{\text{GFM of geraniol}}$ <p>ie $15.4 \times (210 / 154)$</p> <p>or</p> <p>Moles of geraniol x GFM of ester</p> <p>ie 0.1×210</p> <p>(Either of these two steps on their own with all correct substitutions 2 marks)</p> <p>1 mark for calculated final answer provided the concept mark has been awarded.</p>	3	<p>No units required but a maximum of two marks can be awarded if wrong unit is given.</p> <p>(Wrong units are only penalised once in any paper)</p>
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The END