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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2024

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 1

assessing

Basic concepts in Physical
and Inorganic Chemistry



SCH14

[SCH14]

TUESDAY 14 MAY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all sixteen** questions in **Sections A and B**.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen or a pencil.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.

Quality of written communication will be assessed in Question **16(a)**.

The figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included with this question paper.



Section A

For each of the following questions, only **one** of the lettered responses (A–D) is correct.

Select the correct response for each question and write the appropriate letter in the space provided.

- 1 Which one of the following shows the total number of bonding pairs of electrons and lone pairs of electrons in the outer shells of the atoms of BeCl_2 ?

	Number of bonding pairs of electrons	Number of lone pairs of electrons
A	2	0
B	2	2
C	2	6
D	4	6

Answer _____ [1]

- 2 Which one of the following is a reagent used in the test for the ammonium ion?

- A chlorine water
- B hydrochloric acid
- C sodium hydroxide solution
- D starch solution

Answer _____ [1]

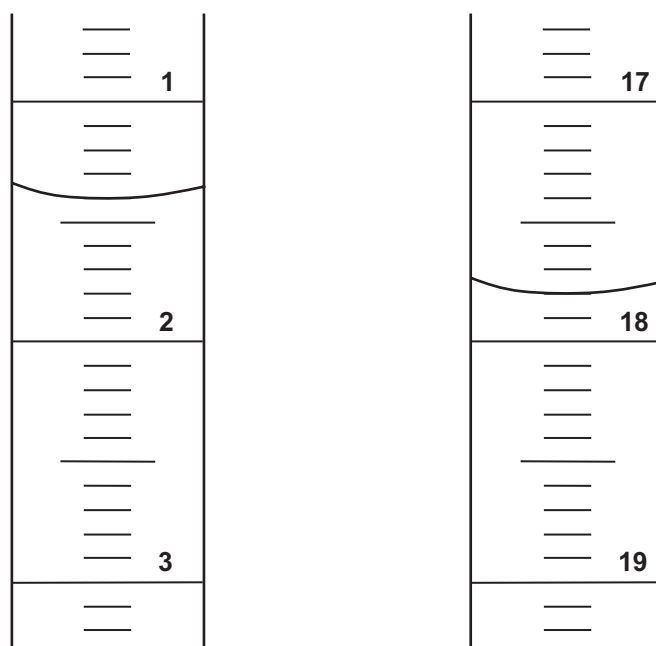


3 Which one of the following has the highest boiling point?

- A CH₄
- B HCl
- C H₂O
- D NH₃

Answer _____ [1]

4 The diagrams below show the initial and final burette readings for a titration.



Which one of the following is the titre value for this titration?

- A 15.6 cm³
- B 16.4 cm³
- C 17.8 cm³
- D 19.2 cm³

Answer _____ [1]

[Turn over

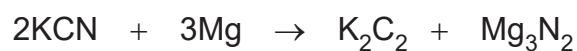


5 Which one of the following is the number of uranium atoms in a sample of 417 mg of U_2O_5 ?

- A 2.28×10^{20}
- B 4.52×10^{20}
- C 9.03×10^{20}
- D 2.26×10^{21}

Answer _____ [1]

6 10.0 g of potassium cyanide are allowed to react with 10.0 g of magnesium. The equation for the reaction is given below.



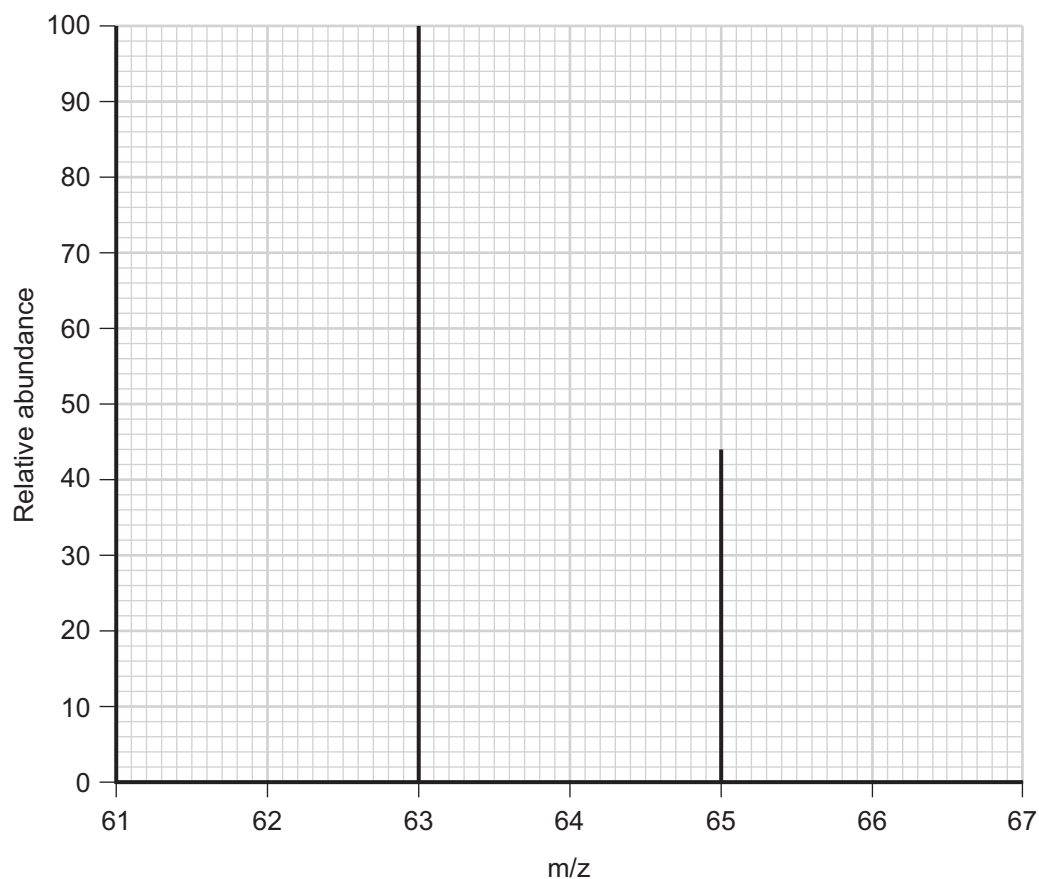
Which one of the following is the mass of magnesium remaining when the reaction is complete?

- A 3.7 g
- B 4.5 g
- C 7.4 g
- D 8.2 g

Answer _____ [1]



7 The mass spectrum of a sample of an element is shown below.



Which one of the following is the relative atomic mass of the element to 1 decimal place?

- A 63.4
- B 63.6
- C 63.8
- D 64.0

Answer _____ [1]

[Turn over

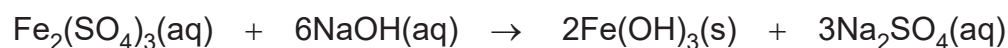


8 Which one of the following is the total number of subatomic particles in an atom of ^{37}Cl ?

- A 17
- B 20
- C 37
- D 54

Answer _____ [1]

9 150 cm^3 of sodium hydroxide solution (an excess) were added to 250 cm^3 of a solution of iron(III) sulfate. 0.428 g of solid iron(III) hydroxide are formed. The equation for the reaction is:



Which one of the following is the concentration, in mol dm^{-3} , of sulfate ions in the final solution?

- A 0.005
- B 0.010
- C 0.015
- D 0.024

Answer _____ [1]



10 In which one of the following molecules do all atoms in the molecule follow the octet rule?

- A BF_3
- B NCl_3
- C PCl_5
- D SO_2

Answer _____ [1]



Section B

Answer **all six** questions in this section.

- 11 The table below shows some details of five chemical tests used to identify the ions present in a solution or in a solid sample. The tests are labelled **A** to **E**.

Test	Practical procedure	Observations	Ion present
A	Add 1 cm ³ of silver nitrate solution to a solution	white precipitate	
B	Add 1 cm ³ of dilute hydrochloric acid to a solid sample		carbonate
C			sulfate
D	Add a few drops of concentrated sulfuric acid to a solid sample	misty fumes red-brown vapour	
E	Carry out a flame test on a solid sample		copper(II)

- (a) Complete the table.

[6]

- (b) What would be observed if excess dilute ammonia solution was added to the solution containing the white precipitate in Test **A**?

[1]



(c) Write an ionic equation for the reaction of the carbonate ion in Test B.

_____ [1]

(d) Name the red-brown vapour in Test D.

_____ [1]

(e) How would the observations in Test D differ if concentrated phosphoric acid was used in place of concentrated sulfuric acid? Explain your answer.

_____ [2]

[Turn over



12 Gallium (atomic number 31) forms many compounds including gallane, GaH_3 , and gallium(III) nitrate which is used to treat some bone disorders.

(a) Gallane is a colourless gas at room temperature. The shape of a gallane molecule is trigonal planar. Gallane is non-polar.

(i) Draw a dot and cross diagram to show the bonding in a molecule of gallane.

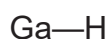
[1]

(ii) Suggest the bond angle in a molecule of gallane.

[1]

(b) The electronegativity of gallium is 1.6 and the electronegativity of hydrogen is 2.1.

(i) Show the polarity of the Ga—H bond using partial charges.



[1]

(ii) Explain why gallane is non-polar.

[1]



(c) Gallane, GaH_3 , forms when lithium tetrahydridogallate(III), LiGaH_4 , reacts with gallium(III) chloride. The only other product is lithium chloride. Lithium tetrahydridogallate(III) contains the tetrahydridogallate(III) ion, GaH_4^- .

(i) Write an equation for the reaction of lithium tetrahydridogallate(III) with gallium(III) chloride.

_____ [2]

(ii) Suggest the shape of the tetrahydridogallate(III) ion, GaH_4^- .

_____ [1]

(iii) A hydride ion bonds with gallane to form the tetrahydridogallate(III) ion. Explain how a hydride ion bonds with gallane and name the type of bond formed.

_____ [2]

(d) Gallane reacts with strong acids to form gallium(III) salts and hydrogen gas.

(i) Write an equation for the reaction of gallane with sulfuric acid.

_____ [2]

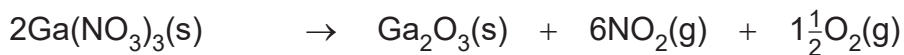
(ii) Describe how you would test for hydrogen gas.

_____ [1]

[Turn over



- (e) One hydrated form of gallium(III) nitrate, $\text{Ga}(\text{NO}_3)_3 \cdot 8\text{H}_2\text{O}$, is heated to constant mass. During this process, it loses its water of crystallisation and the gallium(III) nitrate also decomposes to form gallium(III) oxide, Ga_2O_3 , nitrogen dioxide gas and oxygen gas. The equations for the reactions are:



- (i) Define the term **water of crystallisation**.

_____ [1]

- (ii) Calculate the total loss in mass when a sample of 3.15 g of hydrated gallium(III) nitrate is heated to constant mass. Give your answer to 3 significant figures.

Answer _____ g [4]

- (iii) Suggest one reason why the actual loss in mass obtained practically may not be the same as the value calculated in (e)(ii).

_____ [1]





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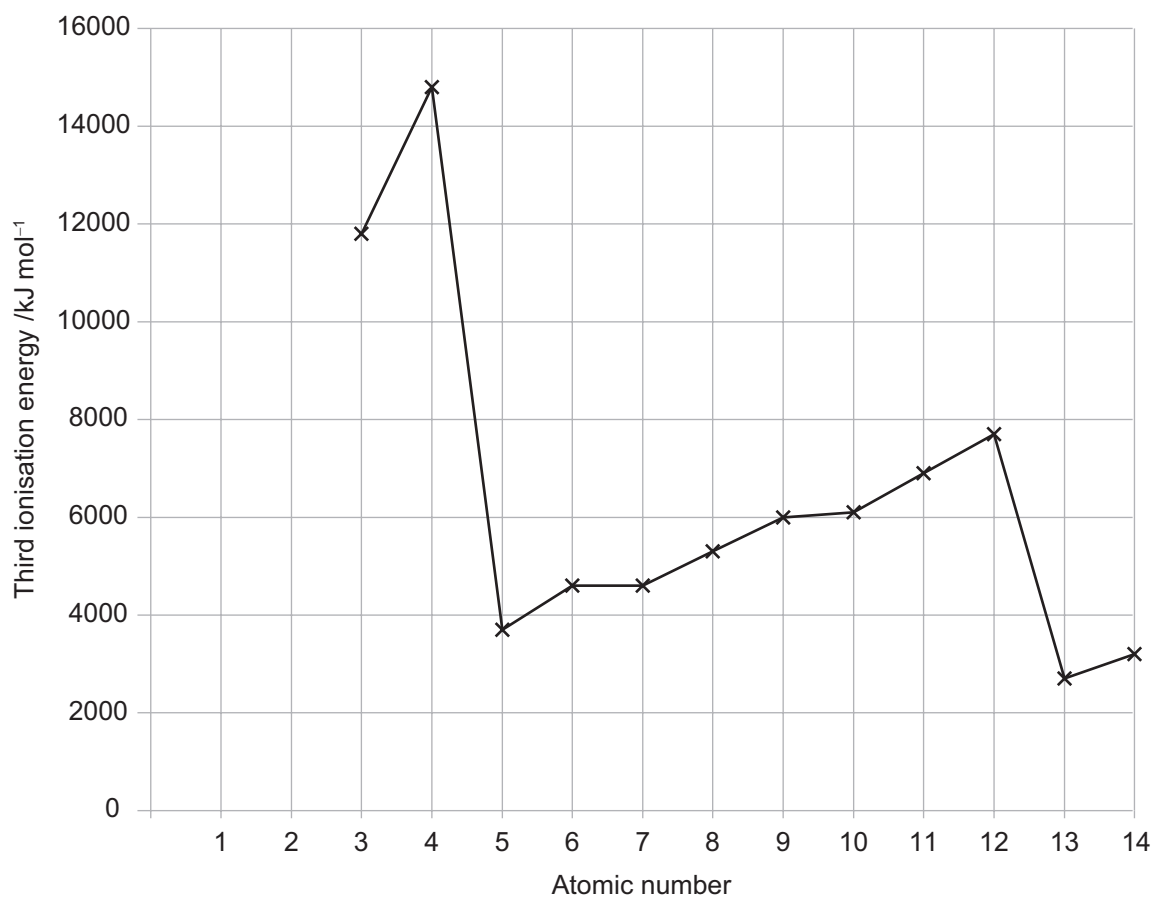
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[Turn over



24SCH1413

- 13 (a) The graph below shows the **third** ionisation energies of elements with atomic numbers 3–14.



- (i) Define the term **third ionisation energy**.

[2]

- (ii) Explain why there are no values for the elements with atomic numbers 1 and 2.

[1]



(iii) Write an equation which represents the third ionisation energy of fluorine.

_____ [1]

(iv) Explain, giving three reasons, why the value of the third ionisation energy of the element with atomic number 12 is significantly greater than the value of the third ionisation energy of the element with atomic number 13.

_____ [3]

(v) State one factor which would explain the general increase in the value of the third ionisation energy from the element with atomic number 5 to the element with atomic number 12.

_____ [1]

[Turn over

13885



24SCH1415

(b) Elements with atomic numbers 23, 24 and 25 are vanadium, chromium and manganese. All three elements form a 2+ ion.

(i) Complete the table below to give the electronic configuration of the atoms of these elements and their 2+ ion.

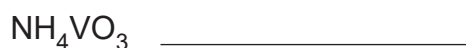
Element	Electronic configuration of atom	Electronic configuration of 2+ ion
V		$1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
Cr		
Mn	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$	

[3]

(ii) Based on the electronic configurations, state and explain which 2+ ion would be most stable.

[2]

(iii) Deduce the oxidation state of Cr, V and Mn in the compounds and ions below.



[2]



- (c) Manganate(VII) ions may be used to oxidise sulfate(IV) ions, SO_3^{2-} , to sulfate(VI) ions. The half-equation for the reduction of manganate(VII) ions, MnO_4^- , to manganese(II) ions, Mn^{2+} is:



- (i) Write a half-equation for the oxidation of sulfate(IV) ions to sulfate(VI) ions.

_____ [2]

- (ii) Write a redox equation for the overall reaction between manganate(VII) ions and sulfate(IV) ions.

_____ [2]

[Turn over



14 Substances can be classified based on their bonding and structure. In general, substances within the same classification have similar physical properties.

(a) Write the **formula** of one example of each of the following:

A molecular covalent element with a relative formula mass greater than 200.

A non-polar covalent compound containing oxygen

A polar covalent compound which dissolves in water forming an alkaline solution.

[3]



(b) Graphite and diamond are classified as giant covalent. There are similarities in the physical properties of graphite and diamond but also some differences, for example graphite conducts electricity and diamond does not.

(i) Describe how the bonding in graphite and in diamond results in the difference in their electrical conductivity.

[3]

(ii) State and explain, in terms of bonding and structure, one **other** difference in the physical properties of graphite and diamond.

[3]

(iii) State and explain, in terms of bonding and structure, one similarity in the physical properties of graphite and diamond.

[2]

[Turn over



- 15 The halogens (Group VII) are a group of highly reactive non-metals. They form ions and compounds in which the halogen has a variety of oxidation states. The main oxidation states of the halogens are shown in the table below. All elements can exist in the -1 oxidation state as halide ions.

Element	Oxidation states
Fluorine	-1
Chlorine	$-1, +1, +3, +5, +7$
Bromine	$-1, +1, +3, +5, +7$
Iodine	$-1, +1, +3, +5, +7$

- (a) Suggest why fluorine does not exist in positive oxidation states.

[1]

- (b) Chlorine reacts with sodium hydroxide solution in one of two ways depending on the conditions used. Both reactions are examples of disproportionation.

- (i) Define **disproportionation**.

[1]

- (ii) Write an equation for the reaction of chlorine with sodium hydroxide solution forming products with chlorine in -1 and $+5$ oxidation states.

[2]



(iii) State the conditions required for the reaction in (b)(ii).

_____ [1]

(c) Write the formula of potassium chlorate(VII).

_____ [1]

(d) Chlorine is a stronger oxidising agent than iodine.

(i) Define **oxidising agent**.

_____ [1]

(ii) Write an equation for the redox reaction which occurs when chlorine reacts with a solution of potassium iodide.

_____ [1]

(iii) State the colour change observed in the solution during the reaction in (d)(ii).

_____ [1]

[Turn over



(b) (i) Calculate the volume of sodium hydroxide solution, in cm^3 , which would be required to react with a 25.0 cm^3 sample of the tartaric acid solution. Give your answer to an appropriate number of significant figures.

Answer _____ cm^3 [5]

(ii) Suggest why the volume of sodium hydroxide solution calculated in (b)(i) may be different to the mean titre value in the titration.

_____ [1]

THIS IS THE END OF THE QUESTION PAPER



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For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
Examiner Number	Total Marks

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General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm³

Avogadro Constant = 6.02×10^{23} mol⁻¹

Planck Constant = 6.63×10^{-34} Js

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ ms}^{-1}$



Characteristic absorptions in IR spectroscopy

Wavenumber/cm ⁻¹	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C ₆ H ₅ –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C ₆ H ₅	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

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chemistry

