

Answer ALL the questions. Write your answers in the spaces provided.

1. The reactions of two solid salts **A** and **B** are given in the tables below. In each case complete the inference column and identify the solid.

(a)

Test	Observations	Inference
Solid A was heated with sodium hydroxide solution and the gas evolved tested with damp red litmus paper.	Colourless gas evolved that turned damp red litmus blue.	Gas evolved Cation in A
Barium chloride solution and dilute hydrochloric acid were added to a solution of A .	White precipitate produced.	Anion in A

Formula of **A**

(4)

(b) **B** contains three elements.

Test	Observations	Inference
Flame test on solid B .	Bright yellow flame.	Cation
Heat solid B and test gas evolved with glowing splint.	Glowing splint ignited.	Gas evolved
Dissolve the residue from the heating of solid B in water. Add silver nitrate solution and dilute nitric acid. Test any precipitate formed with dilute ammonia solution.	White precipitate formed which dissolves in dilute ammonia solution.	Anion in residue

Suggest a name, or formula, for the solid compound **B**.

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(4)

Q1

(Total 8 marks)



2. Suggest how samples of the following substances can be distinguished. You should give a **positive** test for each compound.

(a) Carbon dioxide gas and sulphur dioxide gas.

Carbon dioxide

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Sulphur dioxide

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(3)

(b) A solution of sodium carbonate and a solution of sodium hydrogencarbonate. You are **not** required to prove that sodium is present.

Sodium carbonate

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Sodium hydrogencarbonate

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(4)

(Total 7 marks)

Q2



3. Before a solution of hydrochloric acid can be used in volumetric analysis, its concentration must be found accurately.

(a) Suggest why hydrochloric acid cannot be made up as an accurate (standard) solution from pure hydrogen chloride.

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(1)

(b) The accurate concentration of a solution of hydrochloric acid can be found by titrating it against a standard solution of sodium carbonate.

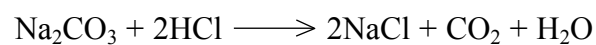
This is made by dissolving a known mass of anhydrous sodium carbonate, Na₂CO₃, in distilled water. Distilled water is added to make the solution up to exactly 250 cm³ in a graduated flask.

Give ONE reason why the sodium carbonate is dissolved in distilled water and then made up to 250 cm³ of solution, rather than just dissolved in 250 cm³ of distilled water.

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(1)

(c) The following results were obtained for the titration of 25.0 cm³ of 0.0500 mol dm⁻³ sodium carbonate solution, Na₂CO₃, against hydrochloric acid.



Number of titration	1	2	3
Burette reading (final)/cm ³	31.10	32.55	30.30
Burette reading (initial)/cm ³	0.00	2.05	0.00
Volume of HCl used/cm ³	31.10	30.50	30.30



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- (i) Which TWO titrations should be used to calculate the mean (average) titre?
Explain your answer.

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(2)

- (ii) Calculate the mean titre.

(1)

- (iii) Calculate the amount (moles) of sodium carbonate, Na_2CO_3 , in 25.0 cm^3 of the $0.0500 \text{ mol dm}^{-3}$ solution.

(1)

- (iv) Hence calculate the amount (moles) of hydrogen chloride, HCl , used.

(1)

- (v) Calculate the concentration of the hydrochloric acid solution to **three** significant figures.

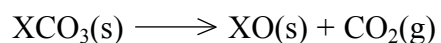
(2)

Q3

(Total 9 marks)



4. A metal carbonate decomposes on heating to give an oxide and carbon dioxide.



where **X** is the metallic element.

In an experiment to find the identity of **X**, 5.75 g of the solid XCO_3 was heated until there was no further change in mass; 3.55 g of solid XO was produced.

- (a) Explain why it was necessary to heat the carbonate until there was no further change in mass.

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 (1)

- (b) (i) Calculate the mass of carbon dioxide gas given off.
 (1)

- (ii) Calculate the amount (moles) of carbon dioxide gas given off.
 (1)

- (iii) Use the answer from (ii) to state the amount (moles) of XCO_3 in 5.75 g of the solid.

 (1)

- (iv) Calculate the molar mass of XCO_3 .
 (1)

- (v) Use your answer from (iv) and the relative atomic masses of carbon and oxygen to calculate the relative atomic mass of **X** in XCO_3 .
 (1)



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(c) All measurements of mass have some uncertainty. In this case, this leads to an error of $\pm 0.91\%$ in the molar mass of XCO_3 .

(i) Use this information and your answer to (b)(iv) to calculate the error in the molar mass of XCO_3 .

(1)

(ii) Hence suggest the range of possible values for the molar mass of XCO_3 .

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(1)

(iii) Hence give the range of possible values of the relative atomic mass of **X**.

(1)

(iv) Use the Periodic Table and your answer to (c)(iii) to suggest possible identities of metal **X**.

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(1)

(Total 10 marks)

Q4

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5. (a) An organic compound **Z** undergoes the following reactions. Complete the table.

Test	Observation	Inference
Bromine water was added drop by drop to Z .	Bromine water goes from brown to colourless.	Functional group present in Z
Solid PCl_5 was added to Z .	Steamy fumes were evolved which turned damp blue litmus red.	Functional group present in Z

(2)

(b) **Z** has a molecular formula of $\text{C}_4\text{H}_8\text{O}$.

Suggest the structural formulae of TWO possible isomers of **Z**.

Isomer I

Isomer II

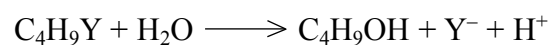
(2)

Q5

(Total 4 marks)



6. Halogenoalkanes react with water to produce alcohols and the halide ion.



(a) The instructions for an experiment to investigate the effect of different halogens on the rate of the substitution reaction are as follows.

- Place 1 cm³ of ethanol in each of three test tubes.
- To one tube add 2 drops of 1-chlorobutane, to the second add 2 drops of 1-bromobutane, and to the third add 2 drops of 1-iodobutane.
- Stand the test tubes in a beaker of hot water.
- When the solutions have reached about 60 °C, add 1 cm³ of aqueous silver nitrate (also at 60 °C) to each tube and start the clock.
- Shake the tubes.
- Note the time taken for a precipitate to form in each tube, and its colour.

(i) Suggest why ethanol was added to each of the tubes.

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 (1)

(ii) Suggest ONE reason why the test tubes were put in the same beaker of hot water.

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 (1)

(iii) Suggest ONE reason why the reaction was carried out at about 60 °C, rather than at room temperature.

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 (1)



(b) State how your observations during the experiment described in (a) could be used to identify which halogen was present in each halogenoalkane. What additional test should be carried out to confirm this? What results would you expect?

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(3)

(c) Outline a test tube experiment, **based on the experiment in (a)**, to investigate how the rate of substitution depends on whether the halogenoalkane is primary, secondary or tertiary.

Base your experiment on the isomeric halogenoalkanes with the formula C_4H_9Br reacting with water.

Your plan should include

- the chemicals you will use
- an outline of how the experiment will be carried out
- the observations or measurements you will make and how you will interpret them

(6)

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THE PERIODIC TABLE

Period **1** **2** **3** **4** **5** **6** **7** **0** Group

Period

1	H
Hydrogen	1

Molar mass g mol ⁻¹
Symbol
Name
Atomic number

4	He
Helium	2

7	Li	9	Be
Lithium	3	Beryllium	4
23	Na	24	Mg
Sodium	11	Magnesium	12
39	K	40	Ca
Potassium	19	Calcium	20
85	Rb	88	Sr
Rubidium	37	Strontium	38
133	Cs	137	Ba
Caesium	55	Barium	56
223	Fr	226	Ra
Francium	87	Radium	88

45	Sc	89	Y	227	Ac
Scandium	21	Yttrium	39	Lanthanum	89

48	Ti	51	V	52	Cr	55	Mn	56	Fe	59	Co	59	Ni	63.5	Cu	65.4	Zn
Titanium	22	Vanadium	23	Chromium	24	Manganese	25	Iron	26	Cobalt	27	Nickel	28	Copper	29	Zinc	30
91	Zr	93	Nb	96	Mo	99	Tc	101	Ru	103	Rh	106	Pd	108	Ag	112	Cd
Zirconium	40	Niobium	41	Molybdenum	42	Technetium	43	Ruthenium	44	Rodium	45	Palladium	46	Silver	47	Cadmium	48
178	Hf	181	Ta	184	W	186	Re	190	Os	192	Ir	195	Pt	197	Au	201	Hg
Hafnium	72	Tantalum	73	Tungsten	74	Rhenium	75	Osmium	76	Iridium	77	Platinum	78	Gold	79	Mercury	80
223	Fr	226	Ra	227	Ac	227	Ac	227	Ac	227	Ac	227	Ac	227	Ac	227	Ac

11	B	12	C	14	N	16	O	19	F	20	Ne
Boron	5	Carbon	6	Nitrogen	7	Oxygen	8	Fluorine	9	Neon	10
27	Al	28	Si	31	P	32	S	35.5	Cl	40	Ar
Aluminium	13	Silicon	14	Phosphorus	15	Sulphur	16	Chlorine	17	Argon	18
70	Ga	73	Ge	75	As	79	Se	80	Br	84	Kr
Gallium	31	Germanium	32	Arsenic	33	Selenium	34	Bromine	35	Krypton	36
115	In	119	Sn	122	Sb	128	Te	127	I	131	Xe
Indium	49	Tin	50	Antimony	51	Tellurium	52	Iodine	53	Xenon	54
204	Tl	207	Pb	209	Bi	210	Po	210	At	222	Rn
Thallium	81	Lead	82	Bismuth	83	Polonium	84	Astatine	85	Radon	86

140	Ce	141	Pr	144	Nd	150	Sm	152	Eu	157	Gd	163	Dy	165	Ho	167	Er	169	Tm	173	Yb	175	Lu
Cerium	58	Praseodymium	59	Neodymium	60	Samarium	62	Euroium	63	Gadolinium	64	Dysprosium	66	Holmium	67	Erbium	68	Thulium	69	Ytterbium	70	Lutetium	71
232	Th	231	Pa	238	U	242	Pu	243	Am	247	Cm	251	Cf	253	Fm	254	No	256	Md	256	Lr	257	Lawrencium
Thorium	90	Protactinium	91	Uranium	92	Plutonium	94	Americium	95	Curium	96	Californium	98	Fermium	100	Nobelium	102	Mendelevium	101	Lawrencium	103	Lawrencium	103

