REDSPOT

IGCSE

(Syllabus 0620)

CHEMISTRY

Paper 4 (Extended) - All Variants

(Topical)

period	2019 to 2024
contents	June & November, Paper 4 (P41, P42 & P43) Worked Solutions
form	Topic By Topic
compiled for	IGCSE

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Website : www.redspot.pk
Address : P.O. Box 5041, Model Town, Lahore, Pakistan.

CONTENTS

TOPIC 2.2

Ionic, Covalent & Metallic Bonding

1. ***[June 2019/P42/Q3 a,b,c,d]***

This question is about phosphorus and compounds of phosphorus.

(a) Phosphorus has the formula P_4. Some properties of P_4 are shown.

melting point / °C	45
boiling point / °C	280
electrical conductivity	non-conductor
solubility in water	insoluble

(i) Name the type of bonding that exists between the atoms in a P_4 molecule.

..... [1]

(ii) Explain, in terms of attractive forces between particles, why P_4 has a low melting point.

.....

..... [1]

(iii) Explain why phosphorus is a non-conductor of electricity.

.....

..... [1]

(b) Phosphorus, P_4, reacts with air to produce phosphorus(V) oxide, P_4O_{10}.

(i) Write a chemical equation for this reaction.

..... [2]

(ii) What type of chemical reaction is this?

..... [1]

(c) Phosphorus(V) oxide, P_4O_{10}, is an acidic oxide.

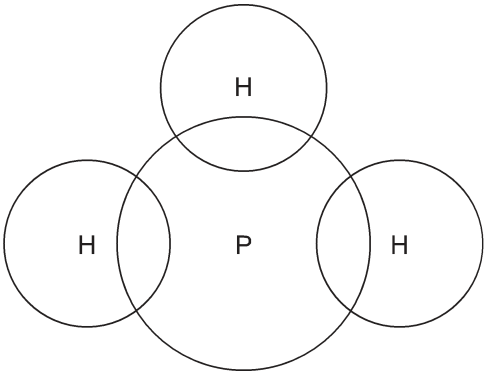
Phosphorus(V) oxide, P_4O_{10}, reacts with aqueous sodium hydroxide to form a salt containing the phosphate ion, PO_4^{3-}. Water is the only other product.

Write a chemical equation for the reaction between phosphorus(V) oxide and aqueous sodium hydroxide.

..... [2]

(d) Phosphine has the formula PH_3.

Complete the dot-and-cross diagram to show the electron arrangement in a molecule of phosphine. Show outer shell electrons only.



[2]

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2. ***[June 2019/P43/Q2 c,d]***

(a) Magnesium is a metal.

Describe the structure and bonding of metals. Include a labelled diagram in your answer.

.....

.....

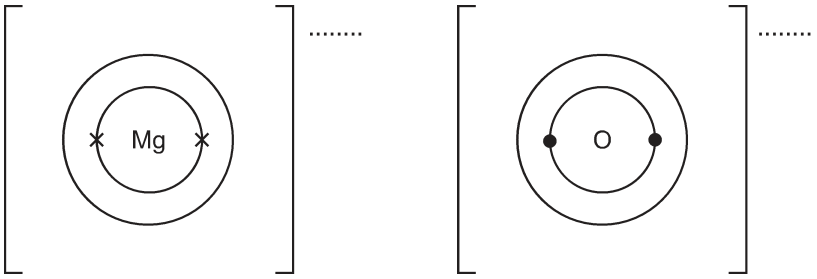
.....

.....

[3]

(b) Magnesium reacts with oxygen to form the ionic compound magnesium oxide.

(i) Complete the dot-and-cross diagrams to show the electronic structures of the ions in magnesium oxide. Show the charges on the ions.



[3]

(ii) Magnesium oxide melts at 2853 °C.

Why does magnesium oxide have a high melting point?

.....

..... [1]

(iii) Explain why molten magnesium oxide can conduct electricity.

.....

.....

..... [1]

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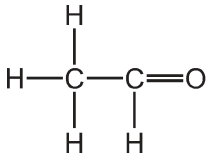
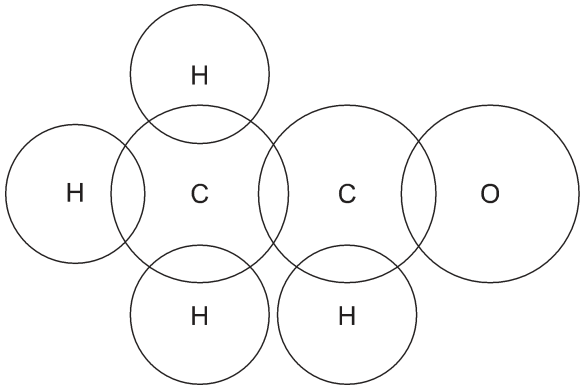
3. ***[Nov 2019/P41/Q7 c(ii,iii)]***

(i) The structure of ethanal is shown.



Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ethanal. Show outer shell electrons only.



[3]

(ii) The table gives the boiling points of ethanal and ethanol.

substance	boiling point / °C
ethanal	20
ethanol	78

In terms of attractive forces between particles, suggest why ethanal has a lower boiling point than ethanol.

.....

..... [1]

---

4. ***[Nov 2019/P43/Q2]***

The table shows the melting points, boiling points and electrical conductivities of six substances **D**, **E**, **F**, **G**, **H** and **I**.

substance	melting point / °C	boiling point / °C	electrical conductivity when solid	electrical conductivity when liquid
D	1610	2230	non-conductor	non-conductor
E	801	1413	non-conductor	good conductor
F	–119	43	non-conductor	non-conductor
G	1535	2750	good conductor	good conductor
H	114	184	non-conductor	non-conductor
I	–210	–196	non-conductor	non-conductor

Choose substances from the table which match the following descriptions. Each substance may be used once, more than once or not at all.

(a) Which substance is a liquid at 25 °C? ..... [1]

(b) Which substance is a gas at 25 °C? ..... [1]

(c) Which **three** substances contain simple molecules?

..... [3]

(d) Which substance could be a metal? Give a reason for your answer.

substance .....

reason .....

.....

[2]

(e) Which substance has a macromolecular structure? Give **two** reasons for your answer.

substance .....

reason 1 .....

reason 2 .....

[3]

(f) Which substance is an ionic solid? Give **one** reason for your answer.

substance .....

reason .....

.....

[2]

5. ***[Nov 2019/P43/Q4 a,b,e,f,g]***

This question is about phosphorus and compounds of phosphorus.

(a) A phosphorus molecule contains four phosphorus atoms **only**.

What is the formula of a phosphorus molecule?

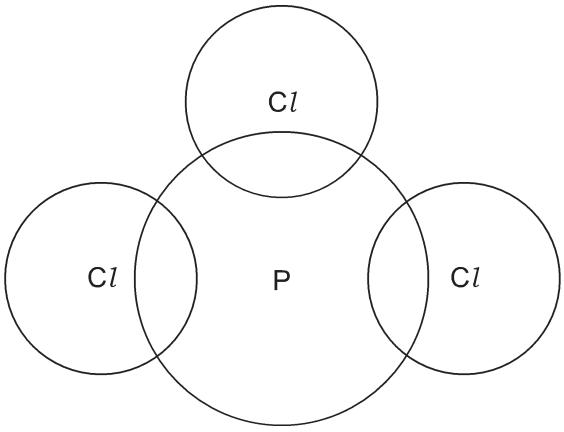
..... [1]

(b) Phosphorus reacts with chlorine gas to produce phosphorus(III) chloride, PCl_3.

(i) Write a chemical equation for the reaction between phosphorus and chlorine to produce phosphorus(III) chloride, PCl_3.

..... [2]

(ii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of phosphorus(III) chloride, PCl_3. Show outer shell electrons only.



[2]

(c) Phosphine, PH_3, is produced by the reaction between water and calcium phosphide, Ca_3P_2.

Balance the chemical equation for this reaction.

$$Ca_3P_2 + ...H_2O \rightarrow .....Ca(OH)_2 + ...PH_3$$

[2]

(d) The phosphonium ion, PH_4^+, is similar to the ammonium ion.

(i) State the formula of the ammonium ion. ..... [1]

(ii) Suggest the formula of phosphonium iodide. ..... [1]

(e) Calcium phosphate contains the phosphate ion, PO_4^{3-}.

What is the formula of calcium phosphate?

..... [1]

6. ***[June 2020/P41/Q2 a,b]***

Magnesium is a metal.

(a) Name and describe the bonding in magnesium.

name .....

description of bonding .....

.....

.....

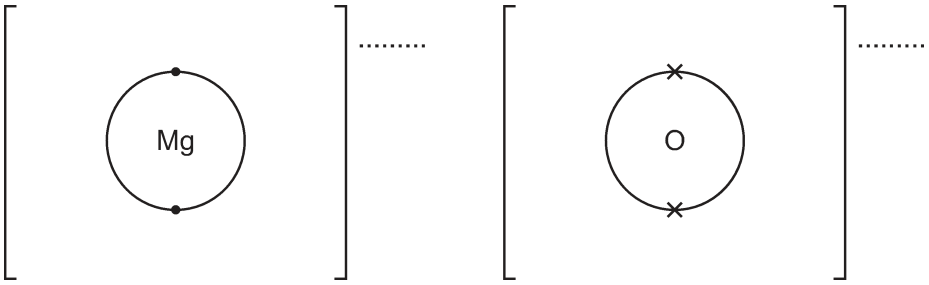
[4]

(b) Magnesium oxide, MgO, is formed when magnesium burns in oxygen.

(i) Complete the dot-and-cross diagram to show the electron arrangement of the ions in magnesium oxide.

The inner shells have been drawn.

Give the charges on the ions.



[3]

(ii) Write the chemical equation for the reaction that occurs when magnesium burns in oxygen.

..... [2]

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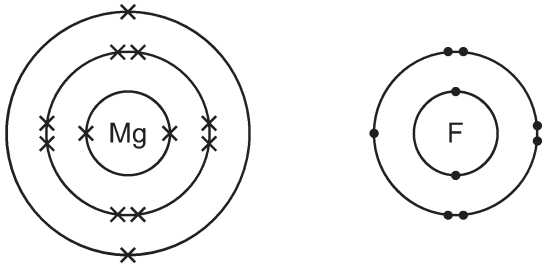
7. ***[June 2020/P42/Q2]***

Fluorine forms both ionic and covalent compounds.

(a) Magnesium reacts with fluorine to form the ionic compound magnesium fluoride.

The electronic structures of an atom of magnesium and an atom of fluorine are shown.



SOLUTIONS

Topic - 2.2

1. **(a)** **(i)** Covalent.

(ii) There are weak forces of attraction between particles in P_4 which need only a small amount of energy to break.

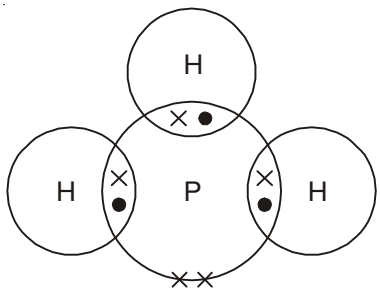
(iii) There are no delocalised ions or electrons present in phosphorus which is why it does not conduct electricity.

(b) **(i)** $P_4 + 5O_2 \rightarrow P_4O_{10}$

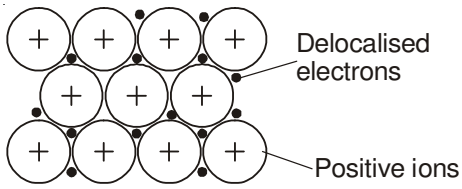
(ii) This is a redox reaction.

(c) $P_4O_{10} + 12NaOH \rightarrow 4Na_3PO_4 + 6H_2O$

(d)

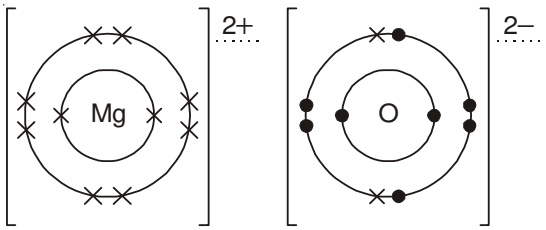


2. **(a)**



Metallic bonding consists of strong forces of attraction between positive ions, arranged in a lattice, and delocalised sea of electrons.

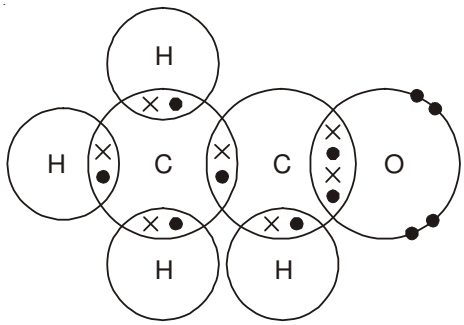
(b) **(i)**



(ii) There are strong forces of attraction between oppositely charged ions in Magnesium oxide which requires high energy to break.

(iii) The cations (Mg^{2+}) and anions (O^{2-}) in magnesium oxide are mobile when in molten form.

3. **(i)**



(ii) In ethanal, the forces of attraction between molecules are weaker than those present between ethanol molecules.

4. **(a)** **F**

(b) **I**

(c) **F**, **H**, **I**

(d) *Substance:* **G**

Reason: As it is a good conductor when solid, **G** is a metal.

(e) *Substance:* **D**

Reason 1: **D** has a high melting point

Reason 2: **D** does not conduct electricity in solid or liquid state.

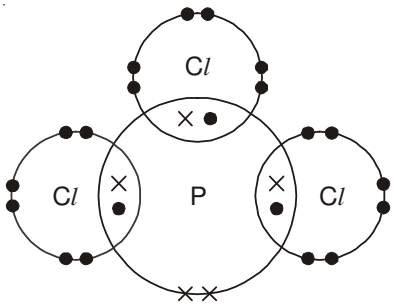
(f) *Substance:* **E**

Reason: **E** only conducts electricity when liquid but not when solid.

5. **(a)** P_4

(b) **(i)** $P_4 + 6Cl_2 \rightarrow 4PCl_3$

(ii)



(c) $Ca_3P_2 + \mathbf{6}H_2O \rightarrow \mathbf{3}Ca(OH)_2 + \mathbf{2}PH_3$

(d) **(i)** NH_4^+

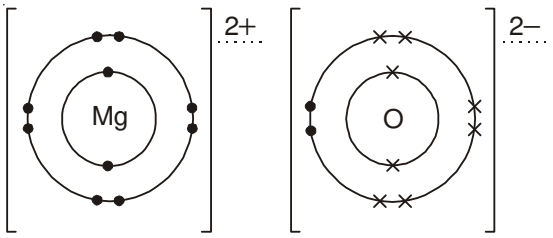
(ii) PH_4I

(e) $Ca_3(PO_4)_2$

6. **(a)** *Name*: Metallic bonding

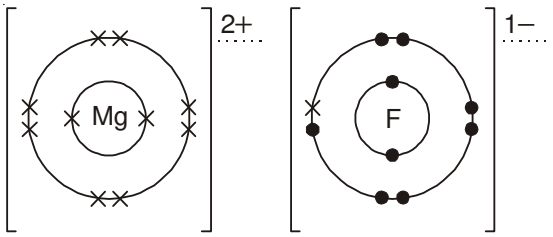
Description of bonding: Strong forces of attraction between a lattice of positive ions and a sea of electrons

(b) **(i)**



(ii) $2Mg + O_2 \rightarrow 2MgO$

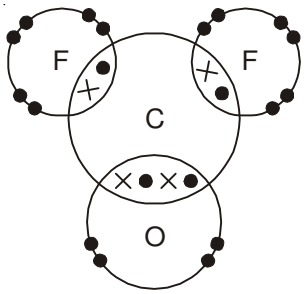
7. **(a)** **(i)**



(ii) MgF_2

(iii) Heating solid MgF_2 to a molten form or dissolving it in water to form an aqueous solution can make it conduct electricity. This is because these changes allows the ions to become mobile enabling conduction of electricity.

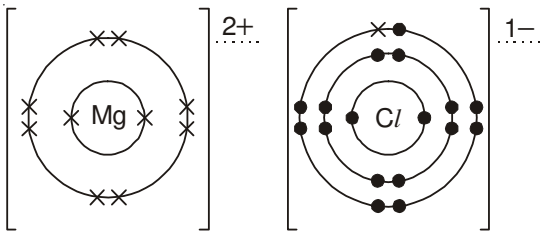
(b)



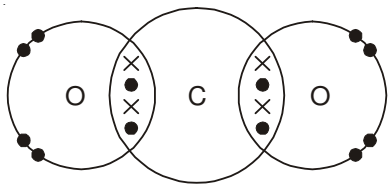
(c) **(i)** Strong forces of attraction exist in ionic bonds between oppositely charged ions. A lot of energy is required to break these bonds.

(ii) There are weak forces of attraction between molecules in carbonyl fluoride which require little energy to break.

8.



9.



10. **(a)** **(i)** **A** and **H**

(ii) **B**

(iii) **D**

(iv) **C** and **G** (Or **C** and **E**)

(b) *Incorrect electronic structure:* **F**

Explanation: In **F**, the third electronic shell is being filled before the second shell is complete.

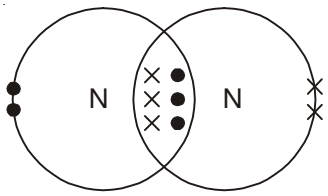
(c) 12

(d) **(i)** H^-

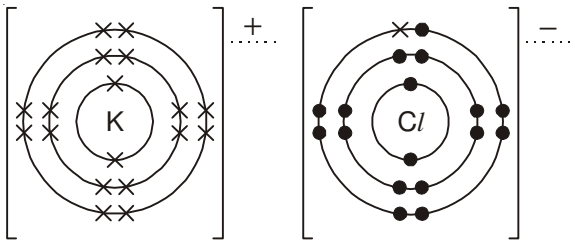
(ii) Aluminium / A*l*

11. In solid state, sodium chloride consists of ions that are fixed in a lattice. However, when in molten state, these ions are mobile and this enables the conduction of electricity.

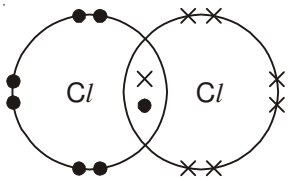
12.



13. (a)



(b)



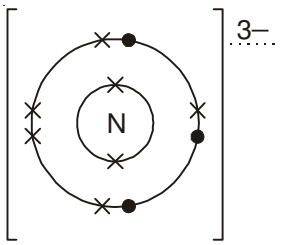
(c) (i) *Physical state:* Liquid.

Explanation: Chlorine melts at –101 °C and boils at –35 °C. As –75 °C lies in between this range, it will exist as a liquid at this temperature.

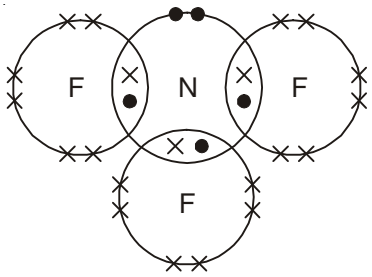
(ii) There are strong ionic compounds present between oppositely charged ions in potassium chloride. On the other hand weak forces of attraction exist between Chlorine molecules. These forces of attraction are easier to overcome as compared to strong ionic bonds in KC*l*.

14. (a) (i) $6Li + N_2 \rightarrow 2Li_3N$

(ii)



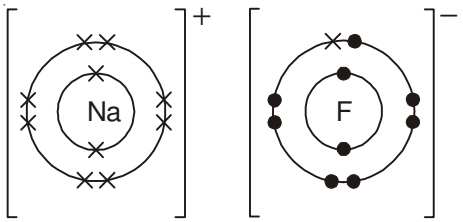
(b)



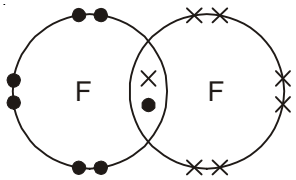
(c) There are strong ionic bonds present in Li_3N while weak forces of attraction exists between molecules of NF_3. In NF_3, the forces of attraction are easier to overcome which is why it has a much lower melting point than Li_3N.

15. (a) $2Na + F_2 \rightarrow 2NaF$

(b)



(c)



(d) (i) *Physical state:* Liquid.

Explanation: Fluorine melts at –220 °C and boils at –188 °C. It remains a liquid in the range in between. –195 °C lies within this range.

(ii) Strong ionic bonds exists in sodium fluoride while weaker forces of attraction exists between molecules in fluorine. These forces in fluorine are easier to overcome and therefore require less energy leading to a low melting point.

16. *Name:* Metallic Bonding.

Description: In metals, the positive ions are fixed in a lattice surrounded by a delocalised sea of electrons. Strong forces of attraction exists between these positive ions and negatively charged electrons.

TOPIC 7.2

Oxides & Preparation of Salts

1. ***[June 2019/P43/Q3 d,e]***

(a) Lead(II) azide is insoluble in water. Solid lead(II) azide can be made in a precipitation reaction between aqueous lead(II) nitrate and aqueous sodium azide.
Lead(II) azide has the formula $Pb(N_3)_2$.

(i) Deduce the formula of the azide ion.

..... [1]

(ii) Complete the chemical equation for the reaction between aqueous lead(II) nitrate and aqueous sodium azide to form solid lead(II) azide and aqueous sodium nitrate. Include state symbols. [2]

$$Pb(NO_3)_2(aq) + ...NaN_3(aq) \rightarrow Pb(N_3)_2(.....) + ...(.....)$$

(iii) Describe how you could obtain a sample of lead(II) azide that is **not** contaminated with any soluble salts from the reaction mixture.

.....

.....

.....

..... [2]

(b) An organic compound made from sodium azide has the composition by mass: 49.5% carbon, 7.2% hydrogen and 43.3% nitrogen.

Calculate the empirical formula of the organic compound.

[3]

2. ***[Nov 2019/P41/Q4]***

Insoluble salts can be made by precipitation reactions.

A student mixed solutions of some soluble salts.

The results the student obtained are shown in the table.

		second salt solution		
		$Co(NO_3)_2(aq)$	$AgNO_3(aq)$	$Pb(NO_3)_2(aq)$
first salt solution	NaI(aq)	no change	yellow precipitate	yellow precipitate
	$Na_2CO_3(aq)$	purple precipitate	yellow precipitate	white precipitate
	$Na_2SO_4(aq)$	no change	white precipitate	white precipitate

All sodium salts are soluble in water.
Use only results from the table to answer the following questions.

(a) Name:

(i) an insoluble cobalt salt ..... [1]

(ii) an insoluble yellow lead salt. ..... [1]

(b) Write the chemical equation for the reaction in which silver carbonate is formed.

..... [2]

(c) Write the ionic equation for the reaction in which lead(II) iodide is formed.

..... [2]

(d) Aqueous silver nitrate produces a yellow precipitate with both iodide ions and carbonate ions. When testing an unknown solution for iodide ions, the aqueous silver nitrate is acidified.

Explain why the aqueous silver nitrate is acidified.

.....

..... [1]

---

3. ***[Nov 2020/P42/Q2 a,b,c,d,e]***

Soluble salts can be made by adding a metal carbonate to a dilute acid.

(a) Give the formula of the dilute acid which reacts with a metal carbonate to form a nitrate salt.

..... [1]

(b) A student wanted to make hydrated iron(II) sulfate crystals, $FeSO_4 \cdot xH_2O$, by adding excess iron(II) carbonate to dilute sulfuric acid. The student followed the procedure shown.

step 1 Add dilute sulfuric acid to a beaker.

step 2 Add small amounts of iron(II) carbonate to the dilute sulfuric acid in the beaker until the iron(II) carbonate is in excess.

step 3 Filter the mixture formed in **step 2**.

step 4 Heat the filtrate until it is a saturated solution. Allow to cool.

step 5 Once cold, pour away the remaining solution. Dry the crystals between filter papers.

(i) Why must the iron(II) carbonate be added in excess in **step 2**?

..... [1]

(ii) State **two** observations in **step 2** that would show that iron(II) carbonate was in excess.

1 .....

2 .....

[2]

(iii) Describe what should be done during **step 3** to ensure there is a maximum yield of crystals.

..... [1]

(iv) A saturated solution is formed in **step 4**.

Describe what a saturated solution is.

.....

..... [2]

(v) Name a different compound that could be used instead of iron(II) carbonate to produce hydrated iron(II) sulfate crystals from dilute sulfuric acid.

..... [1]

(c) On analysing the crystals, the student found that one mole of the hydrated iron(II) sulfate crystals, $FeSO_4 \cdot xH_2O$, had a mass of 278 g.

Determine the value of *x* using the following steps:

- calculate the mass of one mole of $FeSO_4$

mass = ... g

- calculate the mass of H_2O present in one mole of $FeSO_4 \cdot xH_2O$

mass of H_2O = ... g

- determine the value of *x*.

x = ...

[3]

(d) Insoluble salts can be made by mixing solutions of two soluble salts.

A student followed the procedure shown to make silver bromide, an insoluble salt.

step 1 Add aqueous silver nitrate to a beaker. Then add aqueous potassium bromide and stir.

step 2 Filter the mixture formed in **step 1**.

step 3 Dry the residue.

(i) State the term used to describe this method of making salts.

..... [1]

(ii) Give the observation the student would make during **step 1**.

..... [1]

(iii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous potassium bromide.

Include state symbols.

..... [3]

(e) Sodium chloride is an ionic salt. It can be made by reacting sodium with chlorine gas.

The equation for this reaction is shown.

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

Calculate the volume of chlorine gas, in cm^3, that reacts to form 2.34 g of NaCl.

The reaction takes place at room temperature and pressure.

volume of chlorine gas = ... cm^3 [3]

4. ***[June 2021/P41/Q5 a]***

This question is about salts.

Salts that are insoluble in water are made by precipitation.

- Lead(II) iodide, PbI_2, is insoluble in water.
- All nitrates are soluble in water.
- All sodium salts are soluble in water.

You are provided with solid lead(II) nitrate, $Pb(NO_3)_2$, and solid sodium iodide, NaI.

Describe how you would make a pure sample of lead(II) iodide by precipitation.

Your answer should include:

- practical details
- a chemical equation for the precipitation reaction.

.....

.....

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5. ***[June 2021/P42/Q2 b,c]***

(a) Silver nitrate is a salt of silver made by reacting silver oxide with an acid.

Write the formula of the acid which reacts with silver oxide to form silver nitrate.

..... [1]

(b) Aqueous silver nitrate is a colourless solution containing $Ag^+(aq)$ ions.

(i) Describe what is seen when aqueous silver nitrate is added to aqueous sodium iodide, NaI(aq).

..... [1]

(ii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous sodium iodide.

Include state symbols.

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..... [3]

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6. ***[June 2021/P43/Q5 a]***

This question is about salts.

Salts that are soluble in water can be made by the reaction between insoluble carbonates and dilute acids. Zinc sulfate is soluble in water.

You are provided with solid zinc carbonate, $ZnCO_3$, and dilute sulfuric acid, H_2SO_4.

Describe how you would make a pure sample of zinc sulfate crystals.

Your answer should include:

- practical details
- how you would make sure that all the dilute sulfuric acid has reacted
- a chemical equation for the reaction.

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7. ***[Nov 2021/P41/Q2 c]***

Aqueous copper(II) sulfate contains $Cu^{2+}(aq)$ ions.

(i) Describe what is seen when aqueous copper(II) sulfate is added to aqueous sodium hydroxide, NaOH(aq).

..... [1]

(ii) Write the ionic equation for the reaction between aqueous copper(II) sulfate and aqueous sodium hydroxide.

Include state symbols.

.....

..... [3]

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8. ***[Nov 2021/P43/Q3 d,e]***

(a) When lead(II) carbonate is heated it decomposes into lead(II) oxide, PbO, and carbon dioxide.

Write a chemical equation for this reaction.

..... [1]

(b) Lead(II) carbonate reacts with dilute nitric acid. One of the products is aqueous lead(II) nitrate, $Pb(NO_3)_2$.

Write a chemical equation for this reaction.

..... [2]

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9. ***[Nov 2021/P43/Q5 b]***

20.0 cm^3 of dilute sulfuric acid neutralises 25.0 cm^3 of 1.00 mol / dm^3 aqueous sodium hydroxide. At the end of the titration the conical flask contains aqueous sodium sulfate with the dissolved indicator as an impurity.

Describe how to prepare a **pure** sample of sodium sulfate crystals from the original solutions of dilute sulfuric acid and aqueous sodium hydroxide of the same concentrations.

You are not required to give details of how to carry out the titration.

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SOLUTIONS

Topic - 7.2

1. **(a)** **(i)** N_3^-

(ii) $Pb(NO_3)_2(aq) + \mathbf{2}NaN_3(aq) \rightarrow Pb(N_3)_2(\mathbf{s}) + \mathbf{2NaNO_3(aq)}$

(iii) After the reaction, the product mixture is filtered. The residue is washed with water to ensure a pure sample of Lead(II) azide.

(b)

Element	C	H	N
Percentage	49.5	7.2	43.3
No of Moles	$\frac{49.5}{12}$	$\frac{7.2}{1}$	$\frac{43.3}{14}$
=	4.125	7.2	3.093
Simple ratio	$\frac{4.125}{3.093}$	$\frac{7.2}{3.093}$	$\frac{3.093}{3.093}$
=	1.33	2.33	1
=	4	7	3

$\therefore$ Empirical formula is $C_4H_7N_3$

2. **(a)** **(i)** Cobalt carbonate.

(ii) Lead Iodide.

(b) $2AgNO_3 + Na_2CO_3 \rightarrow Ag_2CO_3 + 2NaNO_3$

(c) $Pb^{2+} + 2I^- \rightarrow PbI_2$

(d) Aqueous silver nitrate is acidified so that all the carbonate ions reacts with the acid and only iodide ions are left to test.

3. **(a)** HNO_3

(b) **(i)** In order to make sure all the sulfuric acid has been reacted.

(ii) 1. Remains of solid iron carbonate appears in the reaction mixture.

2. Fizzing stops while there is still solid left.

(iii) The residue should be rinsed with distilled water.

(iv) A saturated solution is the solution in which no more solute can be dissolved at a specific temperature.

(v) Iron(II) hydroxide. (or, iron(II) oxide)

(c) • M_r of $FeSO_4 = 56 + 32 + (16 \times 4)$
$= 152$

• Mass of water $= 278 - 152 = 126$

• Mole of $H_2O = \frac{126}{18} = 7$

$x = 7$

(d) **(i)** Precipitation.

(ii) Cream precipitate observed.

(iii) $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$

(e) M_r of $NaCl = 23 + 35.5 = 58.5$

Moles of $NaCl = \frac{2.34}{58.5} = 0.04$

From equation, $NaCl : Cl_2 = 2 : 1$

$\therefore$ Moles of $Cl_2 = \frac{0.04}{2} = 0.02$

Volume of $Cl_2 = 0.02 \times 24000 = 480\ cm^3$

4. Dissolve both salts together in water to make a solution. They both will react to form precipitates of lead (II) iodide according to the equation:

$$Pb(NO_3)_2 + 2NaI \rightarrow 2NaNO_3 + PbI_2$$

Filter the product solution where lead (II) iodide will be left as residue. The residue is first washed with water to remove any extra product. The residue is first dried using a filter paper and then left to dry in air to obtain pure sample of lead (II) iodide.

5. **(a)** HNO_3

(b) **(i)** Yellow precipitate are observed.

(ii) $Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$

6. The zinc carbonate is added to the sulfuric acid until no more effervescence is observed. Carbon dioxide gas is produced along with zinc sulfate according to the equation:

$$ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + CO_2 + H_2O$$

The product mixture is then filtered. The filtrate is then heated for all the water to evaporate and form dry crystals of zinc sulfate.

7. **(i)** Blue precipitates appear.

(ii) $Cu^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(s)$

8. **(a)** $PbCO_3 \rightarrow PbO + CO_2$

(b) $PbCO_3 + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O + CO_2$

9. The titration is repeated using the same volumes of acid and base but without the indicator. The product solution is heated until most of the water is evaporated. The resulting sample is left to cool down until crystals start to appear. The crystals are then dried using filter paper.

10. **(i)** No further fizzing or effervescence is observed.

(ii) Zinc oxide.

(iii) Powdered zinc carbonate has large surface area which results in more collisions per unit time and hence a higher rate of reaction as compared to lumps of zinc carbonate.

(iv) Crystals form on glass rod if the solution is saturated.

(v) $ZnSO_4$

11. **(a)** • Number of Moles of H_2SO_4

$$= 0.200 \times \frac{50.0}{1000} = 0.01 \text{ moles}$$

• From equation,

$H_2SO_4 : CuSO_4 \cdot 5H_2O = 1 : 1$

$\therefore$ Moles of $CuSO_4 \cdot 5H_2O = 0.01$

• Mass of $CuSO_4 \cdot 5H_2O$

$= 250 \times 0.01 = 2.5$ g

(b) Undissolved solid remains in the solution.

(c) Without heating, the particles have less energy which results in fewer collisions per second. Only a small proportion of particles have energy greater than the activation energy of the reaction which is why only a few of these collisions are successful leading to a lower rate of reaction.

(d) Copper(II) carbonate.
(or Copper(II) hydroxide)

(e) Filtration.

(f) A saturated solution is a solution which can dissolve no more solute at any given temperature.

(g) As heating to dryness forms anhydrous copper (II) sulfate.

12. **(a)** **(i)** Hydrated.

(ii) • M_r of $MgSO_4 = 24 + 32 + (16 \times 4)$

$= 120$

• No. of Moles of $MgSO_4 = \frac{2.4}{120}$

$= 0.02$

• Moles of $MgSO_4 = 0.02$

$\frac{0.02}{0.02} = 1$

Moles of water formed $= 0.140$

$\frac{0.14}{0.02} = 7 \quad \Rightarrow \quad x = 7$

(b) $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$

13. **(a)** $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

(b) **(i)** Lead (II) nitrate

(ii) $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$

(iii) The lead (II) sulfate solution is first filtered to collect pure lead (II) sulfate as residue. The residue is then washed with distilled water and then left to dry in a drying oven (temperature around 100 °C).

14. **(i)** $CuCO_3 + 2HNO_3 \rightarrow Cu(NO_3)_2 + CO_2 + H_2O$

(ii) 1. Undissolved solid is observed.

2. There is no more effervescence even if more copper (II) carbonate is added.

(iii) Copper(II) oxide. (or, Copper(II) hydroxide).