"READY FOR A LEVEL" – INORGANIC CHEMISTRY

1 Silicon and potassium are two elements found in the Earth's crust.

(a) Silicon and potassium both exist as several isotopes.

(a) Define the term *isotope.*

.....

.....

..... **[2]**

(b) Complete the table below for an atom and an ion of two different isotopes of potassium.

	Protons	**Neutrons**	**Electrons**
^{39}K	.....	.....	19
.....	.....	22	18

[2]

(b) Give the electron configuration of a silicon atom.

..... **[1]**

(c) Silicon reacts with chlorine to form molecules of silicon tetrachloride, $SiCl_4$.

How many molecules are present in 8.505 g of $SiCl_4$?

Avogardo's number (N_A) = 6.02×10^{23} mol^{-1}

answer = ... molecules **[3]**

2 The hydrides of Group 5 elements all exist as gases at room temperature.

(a) Phosphine gas, PH_3, can be prepared by adding phosphorus, P_4, to warm concentrated aqueous sodium hydroxide as shown in the equation below.

$$P_4(s) + 3NaOH(aq) + 3H_2O(l) \longrightarrow PH_3(g) + 3NaH_2PO_2(aq)$$

A chemist reacts 1.86 g of P_4 with excess NaOH(aq).

Calculate the volume of phosphine gas, in cm^3, produced at room temperature and pressure, RTP.

volume of phosphine gas = ... cm^3 **[2]**

(b) Phosphine gas burns in air to form an oxide of phosphorus, P_4O_{10}, and water.

Write the equation for this reaction.

..... **[1]**

(c) Phosphoric acid, H_3PO_4, can be made by reacting P_4O_{10} with water.

Sodium phosphate, Na_3PO_4, is a salt that can be prepared by reacting H_3PO_4 with sodium hydroxide, NaOH.

A student prepared a solution of Na_3PO_4 by reacting 15.0 cm^3 of 0.100 $mol\,dm^{-3}$ H_3PO_4 with 0.200 $mol\,dm^{-3}$ NaOH.

(i) Why is Na_3PO_4 described as a salt of H_3PO_4?

.....

..... **[1]**

(ii) Calculate the amount, in moles, of H_3PO_4 in 15.0 cm^3 of 0.100 $mol\,dm^{-3}$ H_3PO_4.

amount = ... mol **[1]**

(iii) The equation for the preparation of Na_3PO_4 from NaOH and H_3PO_4 is shown below.

$$3NaOH(aq) + H_3PO_4(aq) \longrightarrow Na_3PO_4(aq) + 3H_2O(l)$$

Calculate the volume of 0.200 $mol\,dm^{-3}$ NaOH that reacts exactly with 15.0 cm^3 of 0.100 $mol\,dm^{-3}$ H_3PO_4.

volume = ... cm^3 **[1]**

(d) Draw a '*dot-and-cross*' diagram to show the bonding in NH_3.

Show **outer** electrons only.

[2]

3 Group 2 elements react with halogens.

(a) Describe and explain the trend in reactivity of Group 2 elements with chlorine as the group is descended.

In your answer you should use appropriate technical terms, spelled correctly.

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..... **[5]**

TOTAL = 21 marks

ANSWERS

1 Silicon and potassium are two elements found in the Earth's crust.

(a) Silicon and potassium both exist as several isotopes.

(a) Define the term *isotope.*

(Elements with) the same number of protons ✓

But a different number of neutrons / different relative mass ✓

[2]

(b) Complete the table below for an atom and an ion of two different isotopes of potassium.

	Protons	**Neutrons**	**Electrons**
^{39}K	19	20	19
$^{41}K^{+}$	19	22	18

✓ ✓

[2]

(b) Give the electron configuration of a silicon atom.

2, 8, 4 ✓ **[1]**

(c) **(i)** Silicon reacts with chlorine to form molecules of silicon tetrachloride, $SiCl_4$.

How many molecules are present in 8.505 g of $SiCl_4$?

Avogadro's number (N_A) = 6.02×10^{23} mol^{-1}

Relative mass of $SiCl_4$ = 28 + (35.5 x 4) = 170 ✓

Moles of $SiCl_4$ = 8.505 / 170 = 0.0500 moles ✓

Molecules = $0.0500 \times 6.02 \times 10^{23} = 3.01 \times 10^{22}$ ✓

answer = 3.01×10^{22} (✓✓✓) molecules **[3]**

2 The hydrides of Group 5 elements all exist as gases at room temperature.

(a) Phosphine gas, PH_3, can be prepared by adding phosphorus, P_4, to warm concentrated aqueous sodium hydroxide as shown in the equation below.

$$P_4(s) + 3NaOH(aq) + 3H_2O(l) \longrightarrow PH_3(g) + 3NaH_2PO_2(aq)$$

(a) A chemist reacts 1.86 g of P_4 with excess NaOH(aq).

Calculate the volume of phosphine gas, in cm^3, produced at room temperature and pressure, RTP.

Relative mass of P_4 = 4 x 31 = 124 **AND**

Moles of P_4 = 1.86 / 124 = 0.015 moles ✓

Moles of PH_3 = moles of P_4 (1:1 ratio in equation), so…

Volume of PH_3 = 0.015 x 24000 = 360 ✓

volume of phosphine gas = 360 (✓✓) cm^3 **[2]**

(b) Phosphine gas burns in air to form an oxide of phosphorus, P_4O_{10}, and water.

Write the equation for this reaction.

$4\ PH_3 + 8\ O_2 \rightarrow P_4O_{10} + 6\ H_2O$ ✓ **[1]**

(c) Phosphoric acid, H_3PO_4, can be made by reacting P_4O_{10} with water.

Sodium phosphate, Na_3PO_4, is a salt that can be prepared by reacting H_3PO_4 with sodium hydroxide, NaOH.

A student prepared a solution of Na_3PO_4 by reacting 15.0 cm^3 of 0.100 mol dm^{-3} H_3PO_4 with 0.200 mol dm^{-3} NaOH.

(i) Why is Na_3PO_4 described as a salt of H_3PO_4?

H^+ ions in acid have been replaced by metal (Na^+) ions ✓

[1]

(ii) Calculate the amount, in moles, of H_3PO_4 in 15.0 cm^3 of 0.100 mol dm^{-3} H_3PO_4.

Moles = (c x v) / 1000

Moles = (0.100 x 15) / 1000 = 0.0015 moles ✓

amount = 1.50×10^{-3} (✓) mol **[1]**

(iii) The equation for the preparation of Na_3PO_4 from NaOH and H_3PO_4 is shown below.

$$3NaOH(aq) + H_3PO_4(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(l)$$

Calculate the volume of 0.200 mol dm^{-3} NaOH that reacts exactly with 15.0 cm^3 of 0.100 mol dm^{-3} H_3PO_4.

Moles of NaOH = 3 x moles of H_3PO_4 (3:1 ratio in equation), so…

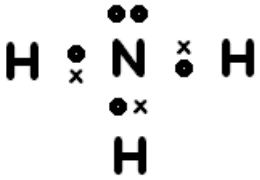
Moles NaOH = 3 x 0.0015 = 0.0045 moles **AND**

Volume = (1000 x 0.0045) / 0.200 = 22.5 cm^3 ✓

volume = 22.5 (✓) cm^3 **[1]**

(d) Draw a '*dot-and-cross*' diagram to show the bonding in NH_3.

Show **outer** electrons only.



3 bonding pairs between N and H with x and • used ✓

Unbonded (lone) pair on N atom ✓

[2]

3 Group 2 elements react with halogens.

(a) Describe and explain the trend in reactivity of Group 2 elements with chlorine as the group is descended.

In your answer you should use appropriate technical terms, spelled correctly.

(Down the group, the group 2 elements…)

Increase in reactivity ✓

(Due to) a greater atomic radius / outer electron(s) further from nucleus ✓

More electron shielding / more full electron shells ✓

Outer electron(s) less strongly attracted to nucleus ✓

Outer electron(s) lost more easily ✓

[5]

TOTAL = 21 marks