# O Level Pure Chemistry Structured

## Chemical Bonding Test 1.0

Q1

A metal verifier is an electronic device that can test for precious metals such as gold, silver and platinum. The verifier works by measuring the resistivity (how much each metal opposes the flow of current) of each metal, which is different for each metal and can therefore easily be distinguished.

The table below shows some information about the resistivity of some common materials. The lower the resistivity, the more readily electric current can flow through that metal.

| metal | resistivity (Ωm) at 20 °C |
|---|---|
| carbon (diamond) | $1.00 \times 10^{12}$ |
| carbon (graphite) | |
| gold | $2.44 \times 10^{-8}$ |
| platinum | $1.06 \times 10^{-7}$ |
| silver | $1.59 \times 10^{-8}$ |

**(a)** Using their structures, explain the difference in resistivity between diamond and the three precious metals.

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.....[2]

**(b)** Will graphite's resistivity be more similar to the metals or diamond? Briefly explain your reasoning.

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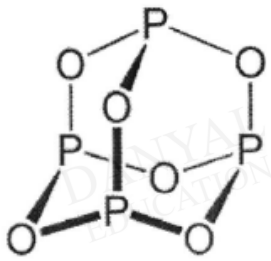
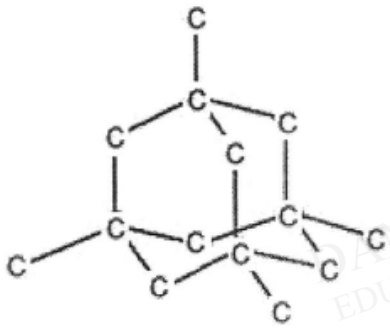
.....[1]

Q2

The structures of phosphorus trioxide and diamond are shown below. Phosphorus trioxide is a covalent compound with a simple molecular structure. Diamond has a giant molecular structure of carbon atoms.




phosphorus trioxide




diamond

**(a)** Write down the molecular formula of phosphorus trioxide.

..... [1]

**(b)** Describe how a *simple molecular structure* differs from a *giant molecular structure*.

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..... [2]

**(c)** Explain why the melting point of phosphorus trioxide is lower than that of diamond.

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..... [3]

**(d)** An oxide was found to have the following composition by mass.

| element | percentage by mass |
|---|---|
| phosphorus | 43.7 |
| oxygen | 56.3 |

Deduce whether this oxide could be phosphorus trioxide by determining its empirical formula.

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..... [3]

[Total: 9]

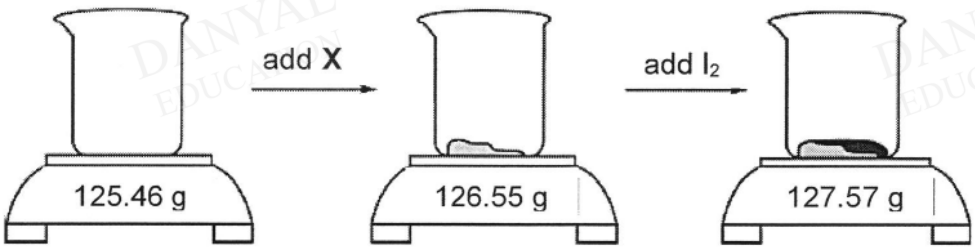
Q3

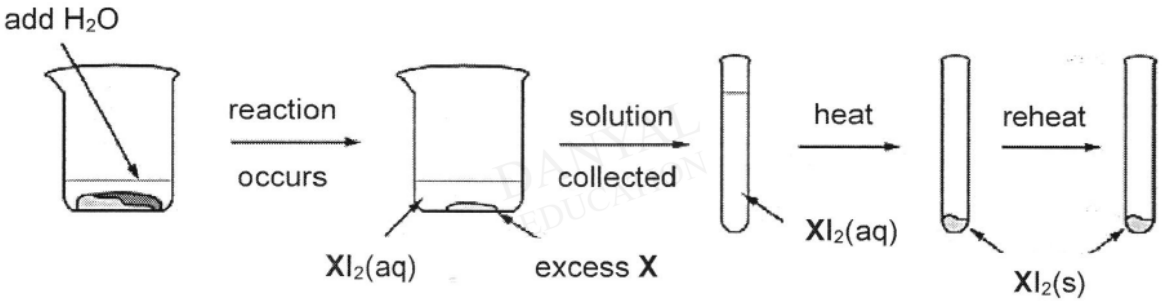
A student conducted an experiment to determine the molar mass of an unknown metal, **X**. The student reacts iodine with an **excess** of the metal to form a water-soluble compound, $\mathbf{X}I_2$.

The equation can be represented below:

$$\mathbf{X} + I_2 \rightarrow \mathbf{X}I_2$$

The reaction proceeds until all of the iodine is used up. The $\mathbf{X}I_2$ solution is collected and heated to remove the water and the product is dried and weighed to a constant mass. The experimental steps are represented and the results are tabulated below.




| | |
|---|---|
| mass of beaker / g | 125.46 |
| mass of beaker + metal **X** / g | 126.55 |
| mass of beaker + metal **X** + $I_2$ / g | 127.57 |
| mass of $\mathbf{X}I_2$ (first weighing) / g | 1.28 |
| mass of $\mathbf{X}I_2$ (second weighing) / g | 1.28 |

**(c)** The student hypothesized that

"the compound formed in the synthesis reaction is ionic"

Propose an experimental test the student could perform in the laboratory to test the hypothesis. Explain how the results of the test would support the hypothesis if the compound is ionic.

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..... [2]

**(d)** The student also hypothesizes that chlorine gas will react with metal **X** more vigorously than solid iodine at room temperature.

Explain, in terms of structure and bonding, why iodine is a solid at room temperature while chlorine is a gas.

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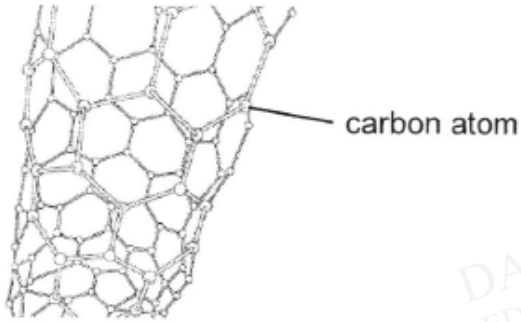
..... [3]

Q4

An airplane contains many miles of electrical wiring made of copper. This adds to the mass of the airplane. It has been suggested that the electrical wiring made of copper could be replaced by lighter carbon nanotubes. The diagram shows the structure of a carbon nanotube. Like graphite, each carbon atom is joined to three other carbon atoms.




**(a)** Explain why the carbon nanotube can conduct electricity.

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..... [2]

**(b)** Another reason why copper is replaced by the carbon nanotubes is that the copper wiring will react eventually with atmospheric oxygen to form copper(II) oxide, decreasing its electrical conductivity.

Explain in terms of its structure and bonding why the metal oxide has a poor electrical conductivity.

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..... [2]

Q5

The head of a match stick contains potassium chlorate and antimony sulfide.

**(a)** Antimony sulfide are added to matches to help them burn more vigorously. Part of its chain structure is shown in Fig. 1.1.

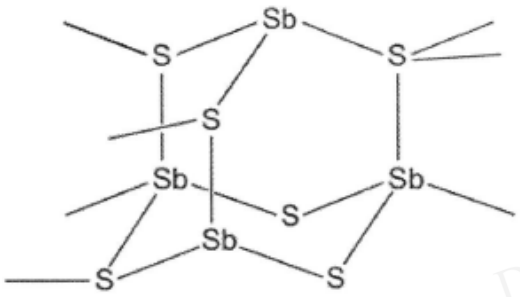


**Fig. 1.1**

With reference to its structure and bonding, explain why antimony sulfide has a high melting point.

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……[2]

**(b)** When a match is struck on the side of the box, the friction produces enough heat to light the match. The equation for the reaction is:

$$5KClO_3 + 6P \rightarrow 5KCl + 3P_2O_5$$

**(i)** Explain, in terms of oxidation state, why potassium chlorate is the oxidising agent in the reaction.

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……[1]

**(b) (ii)** One of the products, phosphorus(V) oxide, $P_2O_5$, absorbs moisture from the air to form metaphosphoric acid, $HPO_3$. On addition of more water, phosphoric acid, $H_3PO_4$, is formed.

Predict and explain the electrical conductivity of the acids formed.

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.....[2]

**(iii)** Show by calculation, which of these acids, $HPO_3$ or $H_3PO_4$, contains the greater percentage of phosphorus by mass.

[2]

[Total: 7]

**Answers**

**Chemical Bonding Test 1.0**

Q1

| | | |
|---|---|---|
| (a) | Diamond does not conduct electricity because all its electrons are already used in covalent bonding. [1]<br>The three precious metals are able to conduct electricity because they have a 'sea' of delocalized electrons that can conduct electricity. [1] | [2] |
| (b) | Graphite's resisitivity will be similar to the metals because graphite has mobile electrons to conduct electricity. | [1] |

Q2

| | | |
|---|---|---|
| A3a | $P_4O_6$ | 1 |
| b | A simple molecular structure has small discrete molecules with weak intermolecular forces while | 1 |
| | a giant molecular structure is a lattice of many atoms covalently bonded together. | 1 |
| c | A small amount of energy is needed to overcome the weak intermolecular forces between the molecules in phosphorus trioxide. | 1<br>1 |
| | A very large amount of energy is needed to overcome the strong covalent bonds between the carbon atoms in the structure of diamond. | 1 |
| d | | |

| element | P | O |
|---|---|---|
| mass (g) / % by mass | 43.7 | 56.3 |
| number of moles | $\frac{43.7}{31} = 1.410$ | $\frac{56.3}{16} = 3.519$ |
| molar ratio | $\frac{1.410}{1.410} = 1$ | $\frac{3.519}{1.410} \approx 2.5$ |
| simplest ratio | 2 | 5 |
| empirical formula | $P_2O_5$ | |

1

Since the empirical formula of phosphorus trioxide is $P_2O_3$, not $P_2O_5$, this oxide cannot be phosphorus trioxide. 1

Q3

| | | |
|---|---|---|
| **(c)** | (1) The student could **dissolve the compound in water** and **test electrical conductivity** of the solution formed.<br><br>If it conducts electricity, the compound has **mobile ions in aqueous state**, thus the compound is likely to be ionic. | [1]<br><br>[1] |
| **(d)** | Both iodine and chlorine are **simple molecules**.<br><br>Iodine molecules are **larger in molecular sizes** compared to chlorine molecules.<br><br>Iodine molecules have **greater intermolecular forces of attraction** than chlorine molecules. More energy is required to overcome the forces of attraction. | [1]<br><br>[1]<br><br>[1] |

Q4

| | | |
|---|---|---|
| **(a)** | Each carbon atom uses 3 out of 4 valence electrons for bonding and<br><br>has 1 unbonded/free valence electron which is mobile to act as charge carrier. (Reject: 'sea of delocalised electrons' without explaining where these electrons come from) | 1<br><br>1 |
| **(b)** | The metal oxide has a giant ionic lattice structure with strong electrostatic forces of attraction between the metal ions and the negative oxide ions.<br><br>In the solid state, the ions are held in fixed arrangement/positions and will not be able to carry electrical charges. | 1<br><br>1 |

Q5

| | | |
|---|---|---|
| **(a)** | Giant molecular structure with strong covalent bonds between antimony and sulfur atoms;<br>A lot of energy needed to overcome the strong forces of attraction; | [1]<br>[1] |
| **(b)(i)** | Oxidation state of phosphorus increased from 0 in phosphorus to +5 in phosphorus(V) oxide; | [1] |
| **(b)(ii)** | Electrical conductors/ can conduct electricity;<br>They have mobile ions in the aqueous state/ when dissolved in water to serve as charge carriers;<br>A: poor/low electrical conductivity<br>A: if only mention mobile $H^+$ ions<br>R: mobile electrons | [1]<br>[1] |
| **(b)(iii)** | % P in $HPO_3$<br>= 31/80 x 100%<br>= 38.75% OR 38.8% (3 sf);<br><br>% P in $H_3PO_4$<br>= 31/98 x 100%<br>= 31.63% OR 31.6% (3 sf);<br>Note: no working no mark<br>R: fractions | [1]<br><br>[1] |