**Q11.**

Which is the correct crystal structure for the substance named?

| | Substance | Structure | |
|---|---|---|---|
| **A** | Iodine | Simple molecular | ⬭ |
| **B** | Diamond | Ionic | ⬭ |
| **C** | Sodium chloride | Giant covalent | ⬭ |
| **D** | Graphite | Metallic | ⬭ |

**(Total 1 mark)**

**Q12.**

This question is about some Period 3 elements and their oxides.

(a) Write an equation for the reaction of phosphorus with an excess of oxygen.

_____

**(1)**

(b) Describe a test you could carry out in a test tube to distinguish between sodium oxide and the product of the reaction in part (a)

_____

_____

_____

_____

_____

_____

**(3)**

(c) State the type of crystal structure shown in silicon dioxide and in sulfur trioxide.

Silicon dioxide _____

Sulfur trioxide _____

**(2)**

(d) Explain why silicon dioxide has a higher melting point than sulfur trioxide.

**(4)**

(e) Write an equation for the reaction of sulfur trioxide with potassium hydroxide solution.

**(1)**

(f) Write an equation for the reaction of an excess of magnesium oxide with phosphoric acid.

**(1)**

(g) Draw the displayed formula of the undissociated acid formed when sulfur dioxide reacts with water.

**(1)**

**(Total 13 marks)**

**Q13.**

This question is about the chemistry of some Group 2 elements.

(a) Write an equation for the reaction of calcium with water at 25 °C and predict a possible value for the pH of the solution formed.

Equation

_____

pH _____

**(2)**

(b) State the trend in solubility, in water, of the Group 2 sulfates from magnesium to barium.

_____

**(1)**

(c) State the trend in solubility, in water, of the Group 2 sulfates from magnesium to barium.

Reagent _____

Equation

_____

**(2)**

(d) Explain why the melting point of calcium sulfate is high.

_____

_____

_____

_____

_____

_____

_____

**(2)**

**(Total 7 marks)**

**Q14.**

This question is about the element iodine and its compounds.

(a) Iodine is in Group 7 of the Periodic Table.

Complete the electron configuration of an iodine atom.

[Kr] _____

**(1)**

(b) Part of the structure of an iodine crystal is shown in the diagram.

Use your knowledge of structure and bonding to explain why the melting point of iodine is low (113.5 °C) and why that of hydrogen iodide is very low (–50.8 °C).

**(6)**

(c) State why iodine does **not** conduct electricity.

_____

_____

_____

**(1)**

(d) Deduce an equation for the formation of hydrogen iodide from its elements.

_____

**(1)**

(e) The triiodide ion is formed when an iodine molecule is bonded to an iodide ion.

What is the formula of ammonium triiodide?

Tick (✓) **one** box.

$NH_3I_3$ ☐

$NH_3I_4$ ☐

$NH_4I$ ☐

$NH_4I_3$ ☐

**(1)**

(f) Draw the shape of the $IF_3$ molecule and the shape of the $IF_4^-$ ion.
Include any lone pairs of electrons that influence each shape.

**(2)**

(g) Deduce the oxidation state of iodine in the following species.

$Ba(IO_3)_2$ _____

$[H_4IO_6]^-$ _____

**(2)**

**(Total 14 marks)**

**Q15.**

The table shows some data about the elements bromine and magnesium.

| Element | Melting point / K | Boiling point / K |
|---|---|---|
| **Bromine** | 266 | 332 |
| **Magnesium** | 923 | 1383 |

In terms of structure and bonding explain why the boiling point of bromine is different from that of magnesium. Suggest why magnesium is a liquid over a much greater temperature range compared to bromine.

**(Total 5 marks)**

**Q16.**

Which substance exists as a macromolecule?

**A** Cu ⬭

**B** $SiO_2$ ⬭

**C** $P_4O_{10}$ ⬭

**D** MgO ⬭

**(Total 1 mark)**

**Q17.**

(a) Van der Waals' forces exist between all molecules.

Explain how these forces arise.

**(3)**

(b) The table shows the boiling points of methanol ($CH_3OH$) and methanethiol ($CH_3SH$).

| Compound | Boiling point / °C |
|---|---|
| Methanol | 65 |
| Methanethiol | 6 |

(i) Explain, in terms of their intermolecular forces, why the boiling points of these compounds are different.

**(3)**

(ii) Suggest how a mixture of methanol and methanethiol could be separated.

**(1)**

(c) Suggest why methaneselenol ($CH_3SeH$) has a higher boiling point than methanethiol ($CH_3SH$).

_____

_____

_____

_____

**(2)**

(d) Sulfur forms many molecular compounds with the halogens.

(i) Draw the shape of an $SF_6$ and of an $SF_4$ molecule.
Include any lone pairs that influence the shape.
State the bond angle(s) in $SF_6$ and in $SF_4$.
Name the shape of $SF_6$.

| | **$SF_6$** | **$SF_4$** |
|---|---|---|
| Shape | | |
| Bond angle(s) | | |
| Name of shape | | |

**(6)**

(ii) $SCl_2$ reacts with NaF to form $SF_4$ and $S_2Cl_2$ and one other product.

Write an equation for the reaction.

_____

**(2)**

**(Total 17 marks)**

**Q18.**

This question is about the periodicity of the Period 3 elements.

(a) State and explain the general trend in first ionisation energy across Period 3.

**(4)**

(b) Give one example of an element which deviates from the general trend in first ionisation energy across Period 3.

Explain why this deviation occurs.

**(3)**

(c) The table shows successive ionisation energies of an element **Y** in Period 3.

| **Ionisation number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| **Ionisation energy / kJ mol$^{-1}$** | 1000 | 2260 | 3390 | 4540 | 6990 | 8490 | 27 100 | 31 700 |

Identify element **Y**.

Explain your answer using data from the table.

**(2)**

(d) Identify the Period 3 element that has the highest melting point.

Explain your answer by reference to structure and bonding.

**(4)**

**(Total 13 marks)**

## Mark Scheme

### Q11.

**A**

**[1]**

### Q12.

(a) $P_4 + 5\ O_2 \longrightarrow P_4O_{10}$

*allow* $4\ P + 5\ O_2 \longrightarrow P_4O_{10}$

*allow multiples*

*ignore state symbols*

**1**

(b) React with water / add water / solution (of substances in question)

*If no M1 then CE = 0/3*

**1**

Add litmus paper / universal indicator / measure pH (with pH meter)

*Allow other reagents in solution, e.g. sodium carbonate solution, that give a positive result*

*Allow other indicators with appropriate colour changes*

**1**

M3 is dependent on M2

Litmus: blue with sodium oxide (solution) **and** red with phosphorus oxide (solution)OR
If blue litmus added phosphorus oxide solution goes red OR
If red litmus added sodium (hydr)oxide goes blue

Universal Indicator: blue/ purple with sodium oxide (solution) **and** red with phosphorus oxide (solution)

pH meter or Universal Indicator: sodium (hydr)oxide (solution) has a higher pH (than phosphorus oxide (solution)) or vv

sodium (hydr)oxide pH (12 to 14) **and** phosphorus oxide (solution) pH (-1 to 2)

*For pH meter or Universal Indicator: allow sodium (hydr)oxide (solution) has a higher pH and phosphorus oxide (solution) has lower pH.*

**1**

(c) For silicon dioxide - giant covalent (molecule)/ macromolecular

**1**

For sulfur trioxide - molecular / (simple) molecule

**1**

*Do not allow simple covalent*

(d) Covalent bonds (between atoms) in $SiO_2$

**1**

Van der Waals between molecules / intermolecular forces in $SO_3$

**1**

Covalent bonds are stronger than van der Waals forces

**1**

(Covalent bonds) take more energy to be overcome/broken or (Van der Waals) take less energy to be overcome/broken

**1**

*If covalent bonds between molecules of $SiO_2$ lose M1 only*
*If hydrogen bonds in $SO_3$ lose M2 only*
*If metallic or ionic max score = 1 (either M1 or M2)*
*If IMF in $SiO_2$ then max 1 ( M2 only)*
*Allow dipole-dipole forces between molecules*
*For M3 and M4 comparison is required/implied*

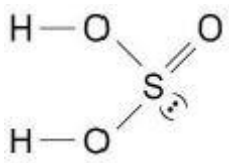
(e) $SO_3 + 2KOH \longrightarrow K_2SO_4 + H_2O$
$SO_3 + KOH \longrightarrow KHSO_4$
$SO_3 + 2OH^- \longrightarrow SO_4^{2-} + H_2O$
$SO_3 + OH^- \longrightarrow HSO_4^-$
*Allow multiples*
*Ignore state symbols*

**1**

(f) $3\ MgO + 2\ H_3PO_4 \longrightarrow Mg_3(PO_4)_2 + 3\ H_2O$
*Allow multiples*
*Ignore state symbols*

**1**

(g)




*Ignore lone pairs*

**1**

**[13]**

## Q13.

(a) $Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$

**1**

8 − 12

**1**

(b) Decrease

**1**

(c) $BaCl_2$
*Allow $Ba(NO_3)_2$ or other soluble barium salt*

**1**

$Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$
*Allow equation if state symbols missing but penalise if state symbols are incorrect*

**1**

(d) Strong attraction

**1**

Between positive and negative ions

**1**

**[7]**

## Q14.

(a) [Kr] $5s^2$ $4d^{10}5p^5$

**1**

(b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

**Level 3**
All stages are covered and the explanation of each stage is correct and complete.

Answer communicates the whole explanation coherently and shows a logical progression from stage 1 to stage 2 and then stage 3.

**5-6 marks**

**Level 2**
All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies **OR** two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.

**3-4 marks**

**Level 1**
Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, **OR** only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.

**1-2 marks**

**Level 0**
Insufficient correct chemistry to warrant a mark.

**0 marks**

***Indicative Chemistry content***

***Stage 1***

*$I_2$ is molecular.*

*HI is molecular.*

***Stage 2***

*IMF hold the molecules together.*

*There are weak IMF forces hence the melting point is low in both substances.*

*$I_2$ bigger molecule than HI so $I_2$ has more electrons.*

***Stage 3***

*Therefore stronger van der Waals between molecules in $I_2$ that need more energy to break causing the melting point to be higher.*

*HI also shows permanent dipole-dipole attraction between molecules but these forces are less than the vdW forces in iodine.*

**6**

(c) No delocalised electrons or ions

**1**

(d) $\frac{1}{2}H_2 + \frac{1}{2}I_2 \longrightarrow HI$

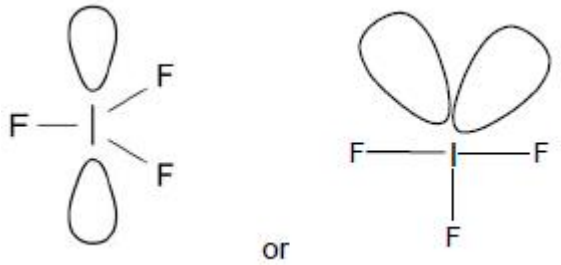
*Allow multiples*

**1**

(e) $NH_4I_3$

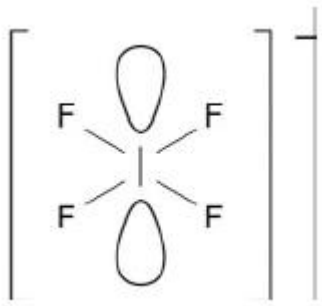
**1**

(f)




*Allow any shape with 3 bond pairs and 2 lone pairs*

**1**




*Allow any shape with 4 bond pairs and 2 lone pairs (e.g. lone pairs in equatorial positions)*

**1**

(g) +5

**1**

+7

**1**

**[14]**

## Q15.

Structures

**M1** Bromine is (simple) molecular / simple molecules

*Chemical Error penalties*

**1**

**M2** Magnesium is metallic / consists of (positive) ions in a (sea) of delocalised electrons

*If $Br_2$ (covalent) bonds broken lose M3 and M4*

**1**

Strength

**M3** $Br_2$ has weak (van der Waals) forces between the molecules / weak IMFs

*If eg Mg molecules or Mg ionic bonds lose M2 and M4*

**1**

**M4** so more energy is needed to overcome the Stronger (metallic) bonds or converse. The comparison could be direct or implied.

**1**

Liquid range

**M5** Mg has a much greater liquid range because forces of attraction in liquid / molten metal are strong(er) OR converse argument for $Br_2$

*Must refer to liquid range to score M5*

**1**

**[5]**

## Q16.

B

**[1]**

## Q17.

(a) Electron movement in first molecule / temporary dipole

*Allow description*

**1**

Induces a dipole in another molecule

*Allow description*

**1**

(Induced-temporary) attraction or δ+ attracts δ- in different/adjacent molecules

*M3 dependent on M1 and M2*

*Allow electrostatic attraction*

*M3 could be scored in diagram*

*If other type of force / metallic / ionic / polar bonds / permanent dipoles / difference in electronegativity mentioned CE = 0*

**1**

(b) (i) (Methanol) H-bonds / hydrogen bonding

**1**

(Methanethiol) dipole-dipole forces or van der Waals

**1**

H-bonds are a stronger / are the strongest IMF

*Allow H-bonds require more energy to overcome*

*If M1 and M2 not scored, allow 1 for methanol has stronger IMFs*

*If breaking covalent bonds then CE=0*

**1**

(ii) (Fractional) distillation

*Allow description*

*Do not allow heating unqualified*

1

(c) (Methaneselenol is a) bigger molecule / larger Mr / larger no of electrons / Se bigger atom

1

With <u>stronger/more</u> <u>vdw</u> forces <u>between molecules</u>

*If breaking covalent bonds then CE=0*

1

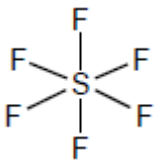
(d) (i) 


*Diagram showing 6 bond pairs*

1

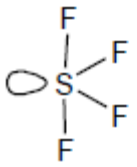
(Bond angle) 90° for $SF_6$

*Ignore 180°*

1

Octahedral

1




or

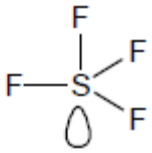



*Diagram showing 4 bond pairs <u>and 1 lone pair</u>*

1

(Bond angles) for $SF_4$

*If shape of $SF_4$ is not based on 4 bond pairs <u>and 1 lone pair</u> cannot score M4 or M5*

Any **two** from:
Allow 85 – 89°

*Do not allow 90°*

Allow 100 – 119°

*Do not allow 120°*

Allow 170 – 179°

*Do not allow 180°*

2

(ii) NaCl (as product in any equation)

1

$3\ SCl_2 + 4\ NaF \rightarrow SF_4 + S_2Cl_2 + 4\ NaCl$

*Allow multiples*

*Ignore states*

1

**[17]**

## Q18.

(a) General increase

*If not increase then CE*

1

Greater nuclear charge / more protons

1

Same shielding / electrons added to same shell

*Allow similar*

1

Stronger attraction (from nucleus) for outer electron(s)

*Allow electron in outer shell*

1

(b) Aluminium / Al (lower than Mg)

*CE if not Al or S*

1

(Outer) electron in (3)p orbital / sub-shell (level)

*If 2p or 4p orbital lose M2 and M3*

1

(3p) higher in energy

*Allow more shielded or weaker nuclear attraction*

*M3 is dependent on M2*

1

or
Sulfur / S (lower than P)
(Outer) electrons in (3)p orbital begin to pair
Repel

*If 2p or 4p orbital lose M2 and M3*

*Allow 2 electrons in (3)p*

*M3 is dependent on M2*

(c) Sulfur / S

*CE if not S*

1

Large jump after 6th or between 6th and 7th

*Do not allow M2 if atom/ion is removed*

1

(d) Silicon

*CE if not Si*

1

Giant covalent structure / macromolecule

1

Covalent (bonds)

*Giant covalent scores M2 and M3*

1

Many / strong (covalent bonds) or
(covalent bonds) need lots of energy to break

*CE for M2-M4 if molecules / metallic / ionic / IMFs mentioned*

1

**[13]**