Q1. This question is about the elements in Period 3 of the Periodic Table.

(a) State the element in Period 3 that has the highest melting point.
Explain your answer.

Element .....

Explanation .....

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(3)

(b) State the element in Period 3 that has the highest first ionisation energy.
Explain your answer.

Element .....

Explanation .....

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(3)

(c) Suggest the element in Period 3 that has the highest electronegativity value.

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(1)

(d) Chlorine is a Period 3 element.
Chlorine forms the molecules ClF_3 and CCl_2

(i) Use your understanding of electron pair repulsion to draw the shape of ClF_3 and the shape of CCl_2
Include any lone pairs of electrons that influence the shape.

Shape of ClF_3 Shape of CCl_2

(2)

(ii) Name the shape of CCl_2

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(1)

(iii) Write an equation to show the formation of one mole of ClF_3 from its elements.

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(1)

(Total 11 marks)

Q2. Aluminium and thallium are elements in Group 3 of the Periodic Table.
Both elements form compounds and ions containing chlorine and bromine.

(a) Write an equation for the formation of aluminium chloride from its elements.

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(1)

(b) An aluminium chloride molecule reacts with a chloride ion to form the $AlCl_4^-$ ion.

Name the type of bond formed in this reaction. Explain how this type of bond is formed in the $AlCl_4^-$ ion.

Type of bond .....

Explanation .....

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(2)

(c) Aluminium chloride has a relative molecular mass of 267 in the gas phase.

Deduce the formula of the aluminium compound that has a relative molecular mass of 267

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(1)

(d) Deduce the name or formula of a compound that has the same number of atoms, the same number of electrons and the same shape as the $AlCl_4^-$ ion.

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(1)

(e) Draw and name the shape of the $TlBr_5^{2-}$ ion.

Shape of the $TlBr_5^{2-}$ ion.

Name of shape .....

(2)

(f) (i) Draw the shape of the $TlCl_2^+$ ion.

(1)

(ii) Explain why the $TlCl_2^+$ ion has the shape that you have drawn in part (f)(i).

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(1)

(g) Which **one** of the first, second or third ionisations of thallium produces an ion with the electron configuration [Xe] $5d^{10}6s^1$?

Tick (✓) one box.

First ☐

Second ☐

Third ☐

(1)
(Total 10 marks)

Q3. Thallium is in Group 3 of the Periodic Table.
Thallium reacts with halogens to form many compounds and ions.

(a) Draw the shape of the $TlBr_3^{2-}$ ion and the shape of the $TlCl_4^{3-}$ ion.
Include any lone pairs of electrons that influence the shapes.

Name the shape made by the atoms in $TlBr_3^{2-}$ and suggest a value for the bond angle.

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(4)

(b) Thallium(I) bromide (TlBr) is a crystalline solid with a melting point of 480 °C.

Suggest the type of bonding present in thallium(I) bromide and state why the melting point is high.

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(3)

(c) Write an equation to show the formation of thallium(I) bromide from its elements.

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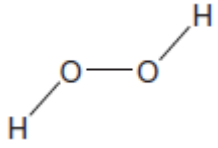
(1)

(Total 8 marks)

Q4. A hydrogen peroxide molecule can be represented by the structure shown.



(a) Suggest a value for the H−O−O bond angle.

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(1)

(b) Hydrogen peroxide dissolves in water.

(i) State the strongest type of interaction that occurs between molecules of hydrogen peroxide and water.

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(1)

(ii) Draw a diagram to show how one molecule of hydrogen peroxide interacts with one molecule of water.
Include all lone pairs and partial charges in your diagram.

(3)

(c) Explain, in terms of electronegativity, why the boiling point of H_2S_2 is lower than H_2O_2.

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(2)
(Total 7 marks)

Q5.(a) Write an equation, including state symbols, for the reaction with enthalpy change equal to the standard enthalpy of formation for $CF_4(g)$.

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(1)

(b) Explain why CF_4 has a bond angle of 109.5°.

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(2)

(c) **Table 1** gives some values of standard enthalpies of formation ($\Delta_f H^\ominus$).

Table 1

Substance	$F_2(g)$	$CF_4(g)$	HF(g)
$\Delta_f H^\ominus$ / kJ mol^{-1}	0	−680	−269

The enthalpy change for the following reaction is −2889 kJ mol^{-1}.

$$C_2H_6(g) + 7F_2(g) \longrightarrow 2CF_4(g) + 6HF(g)$$

Use this value and the standard enthalpies of formation in **Table 1** to calculate the standard enthalpy of formation of $C_2H_6(g)$.

Standard enthalpy of formation of $C_2H_6(g)$ = ... kJ mol^{-1}

(3)

(d) Methane reacts violently with fluorine according to the following equation.

$$CH_4(g) + 4F_2(g) \longrightarrow CF_4(g) + 4HF(g) \quad \Delta H = -1904 \text{ kJ mol}^{-1}$$

Some mean bond enthalpies are given in **Table 2**.

Table 2

Bond	C−H	C−F	H−F
Mean bond enthalpy / kJ mol^{-1}	412	484	562

A student suggested that one reason for the high reactivity of fluorine is a weak F−F bond.

Is the student correct? Justify your answer with a calculation using these data.

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(4)
(Total 10 marks)

Q6.(a) Explain how the electron pair repulsion theory can be used to deduce the shape of, and the bond angle in, PF_3

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(6)

(b) State the full electron configuration of a cobalt(II) ion.

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(1)

(c) Suggest **one** reason why electron pair repulsion theory **cannot** be used to predict the shape of the $[CoCl_4]^{2-}$ ion.

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(1)

(d) Predict the shape of, and the bond angle in, the complex rhodium ion $[RhCl_4]^{2-}$.

Shape .....

Bond angle .....

(2)

(Total 10 marks)

Q7. Which of these species has a trigonal planar structure?

A PH_3 ⬭

B BCl_3 ⬭

C H_3O^+ ⬭

D CH_3^- ⬭

(Total 1 mark)