The **topics** and **types of questions** examined in this Achievement Standard. Use this sheet to plan and organise your study so that you cover everything that is required.



## 3.4 PARTICLES AND THERMOCHEMISTRY AS 90780

Describe properties of particles and thermochemical principles

### 3.4 1. Electron configuration and periodic trends

- electron configuration of atoms and ions of the first 36 elements (s,p,d notation)

▶ Write the electron configuration using s, p, d notation for:

Sc  $Br^-$  $Mn^{2+}$

- special characteristics of transition metals (variable oxidation state, colour) related to electron configuration: limited to iron, vanadium, chromium, manganese, copper and zinc

▶ Explain in terms of electron configuration why zinc sulfate, $ZnSO_4$, forms a colourless solution, whereas copper sulfate, $CuSO_4$, forms a blue solution.

- periodic trends in atomic radius, ionisation energy, electronegativity, comparison of atomic and ionic radii

▶ Account for the following:

(i) A bromine atom, Br, has more electrons than a scandium atom, Sc, but its radius is smaller.

(ii) A bromine atom, Br, is smaller than a scandium atom, Sc, but its ionisation energy is larger.

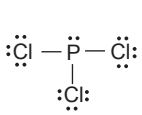
### 3.4 2. Shape and polarity

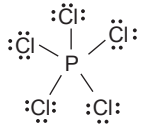
- Lewis structures and shapes (up to six electron pairs about the central atom for molecules and polyatomic ions, including those with multiple bonds).

▶ Draw Lewis diagrams for nitrate ($NO_3^-$) and iodate ($IO_3^-$) ions. Identify the shapes of these two ions and explain why their shapes are different.

- polarity of molecules

▶ Lewis diagrams of $PCl_3$ and $PCl_5$ are shown below.





Discuss the polarities of the $PCl_3$ and $PCl_5$ molecules. In your discussion consider both the relative electronegativity of P and Cl, and the shapes of the molecules.

### 3.4 3. Attractive forces between particles

- attractive forces between atoms, ions and molecules: ionic bonds, covalent bonds, intermolecular attractions due to temporary dipoles and permanent dipoles (including hydrogen bonding).

▶ The boiling points of HF, $F_2$ and HCl are given below:

| Molecule | Boiling point (°C) |
|---|---|
| Hydrogen fluoride, HF | 19.5 |
| Fluorine, $F_2$ | -188.1 |
| Hydrogen chloride, HCl | -85.1 |

Discuss the different boiling points of hydrogen fluoride, fluorine and hydrogen chloride in terms of the relative strengths of the intermolecular forces between the particles involved.

### 3.4 4. Enthalpy changes

- transfer of heat between system and surroundings
- calculations involving the use of specific heat capacity
  $\Delta_c H°$, $\Delta_f H°$, $\Delta_r H°$, $\Delta_{vap} H°$, $\Delta_{sub} H°$, $\Delta_{fus} H°$

▶ The principle of a fireworks-type explosion can be demonstrated by igniting a sucrose jelly baby with sodium chlorate, $NaClO_3$.

The equation for the explosion reaction is:

$$2NaClO_3(s) + C_{12}H_{22}O_{11}(s) \rightarrow 2NaCl(s) + 9C(s) + 3CO_2(g) + 11H_2O(g)$$

$$\Delta_r H° = -2192 \text{ kJ mol}^{-1}$$

Calculate the quantity of heat released when one jelly baby containing 4.56 g of sucrose ($C_{12}H_{22}O_{11}$) is exploded.

$$M(C_{12}H_{22}O_{11}) = 342 \text{ g mol}^{-1}$$

### 3.4 5. Using bond enthalpies

- using bond enthalpies in calculations

▶ (a) Write the equation for the reaction that has an enthalpy change given by $\Delta_f H^o$ (HCl, *g*).

(b) (i) Calculate $\Delta_f H^o$ (HCl, *g*) using the following bond enthalpies.

| Bond | Bond enthalpy / kJ mol$^{-1}$ |
|---|---|
| H–H | 436 |
| Cl–Cl | 242 |
| H–Cl | 431 |

(ii) $\Delta_f H^o$ (HBr, *g*) is –36.2 kJ mol$^{-1}$.

Calculate the heat produced by the formation of 50.0 g of HBr*(g)* from its elements in their standard states.

### 3.4 6. Hess's Law calculations

- Hess's Law including application of:
  $\Delta_r H° = \sum \Delta_f H(\text{products}) - \sum \Delta_f H(\text{reactants})$

▶ (a) The smelting of zinc ores involves the reaction of Zn and ZnS with oxygen gas according to the following equations:

$$Zn(s) + \tfrac{1}{2} O_2(g) \rightarrow ZnO(s) \quad \Delta_r H° = -348 \text{ kJ mol}^{-1}$$

$$ZnS(s) + 1\tfrac{1}{2} O_2(g) \rightarrow ZnO(s) + SO_2(g) \quad \Delta_r H° = -441 \text{ kJ mol}^{-1}$$

Using the following information and the data above,

$$S(s) + O_2(g) \rightarrow SO_2(g) \quad \Delta_f H° = -297 \text{ kJ mol}^{-1}$$

calculate the value of the enthalpy change, $\Delta_r H°$, for the reaction:

$$Zn(s) + S(s) \rightarrow ZnS(s)$$

(b) Using the result of the calculation in part (a) above, describe, with a reason, whether the heat of formation of ZnS is endothermic or exothermic.