| Name: | Teacher: |
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# Level 3 Chemistry

## 91390 Demonstrate understanding of thermochemical principles and the properties of particles and substances

**Credits: Five**

| Achievement | Achievement with Merit | Achievement with Excellence |
|---|---|---|
| Demonstrate understanding of thermochemical principles and the properties of particles and substances. | Demonstrate in-depth understanding of thermochemical principles and the properties of particles and substances. | Demonstrate comprehensive understanding of thermochemical principles and the properties of particles and substances |

You should attempt ALL the questions in this booklet.

A periodic table is provided in the Resource Sheet.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2 – 11 in the correct order and that none of these pages is blank.

**YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.**

**TOTAL**

**ASSESSOR'S USE ONLY**

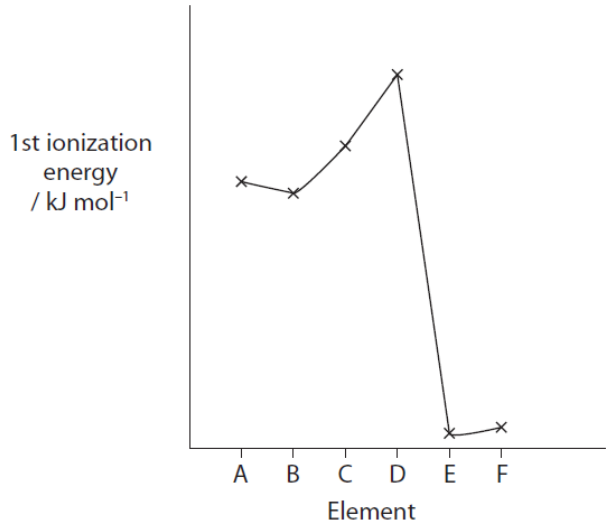
**QUESTION ONE**

(a) Complete the following table, using s, p, d notation.

| Symbol | Electron configuration |
|---|---|
| $Al^{3+}$ | |
| Co | |
| $Fe^{3+}$ | |

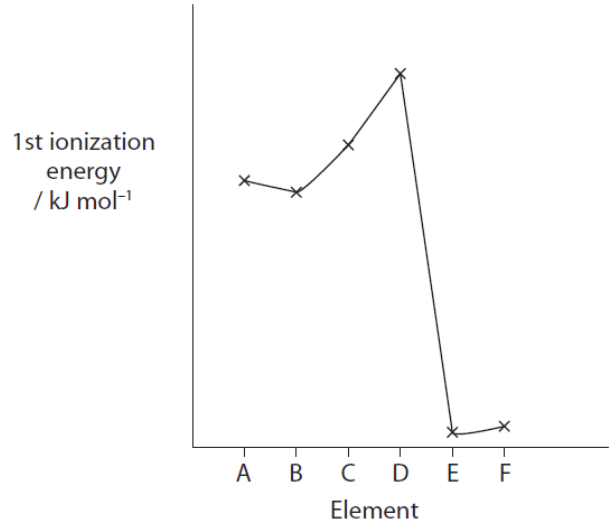
(b) Explain why a potassium ion is smaller than a potassium atom.

(c) The graph shows the first ionization energies for six successive elements in the Periodic Table. The letters used are not their symbols.




(i) Define the term **first ionization energy**.

(ii) Ionisation energies provide evidence for the arrangement of electrons in atoms.




Identify and justify which element (A – F) is potassium.

**Question Two**

(a) Chlorine, Cl and fluorine, F are both halogens. A molecule of $ClF_3$ can react with a molecule of $AsF_5$ as shown in the following equation.

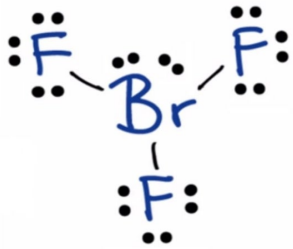
$$\mathbf{ClF_3 + AsF_5 \rightarrow ClF_2^+ + AsF_6^-}$$

Complete the following table.

| | **$AsF_5$** | **$ClF_2^+$** |
|---|---|---|
| Lewis Diagram | | |
| Name of shape | | |

Bromine also forms compounds with other halogens.

(b) The Lewis diagram for the bromine trifluoride molecule is shown below.




Would you expect $BF_3$ to be soluble in water?

**Yes** **No**

Explain your answer in terms of the shape and polarity of $BF_3$.

_____

_____

_____

_____

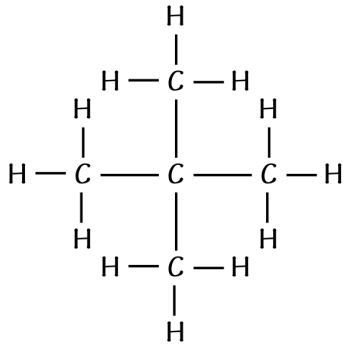
_____

(c) Fluorine reacts with hydrogen to form hydrogen fluoride (HF). The boiling points of fluorine and hydrogen fluoride are –188°C and 19.5°C respectively.
Explain the difference in the boiling points of fluorine and hydrogen fluoride by comparing and contrasting the relative strengths of all the attractive forces involved between the molecules.

(d) The following table shows the boiling points of some straight-chain alkanes.

| | $CH_4$ | $C_2H_6$ | $C_3H_8$ | $C_4H_{10}$ | $C_5H_{12}$ |
|---|---|---|---|---|---|
| Boiling point /$^oC$ | -162 | -88 | -42 | -1 | 36 |

(i) The following compound is an isomer of one of the alkanes in the table. It has a boiling point of 9.5$^o$ C.



Discuss why the boiling point of this compound is lower than that of its straight-chain isomer.

(ii) Both $C_3H_8$ and $C_4H_{10}$ can be liquefied and used as fuels for camping stoves. Suggest, with a reason, which of these two fuels is liquefied more easily.

**QUESTION THREE**

Cracking is the process whereby organic molecules are broken down into simpler molecules

The equation for a cracking reaction of butane is

$$C_4H_{10}(g) \rightarrow CH_4(g) + C_3H_6(g)$$

(a) Use the following standard enthalpy changes of combustion to calculate the enthalpy change of this cracking reaction.

$$\Delta_cH^o(CH_4(g)) = -890 \text{ kJ mol}^{-1}$$

$$\Delta_cH^o(C_4H_{10}(g)) = -2877 \text{ kJ mol}^{-1}$$

$$\Delta_cH^o(C_3H_6(g)) = -2058 \text{ kJ mol}^{-1}$$

Make sure to:

- show your method.
- include a sign and units in your answer.

Propane is sold in small cylinders. It is used as a fuel in camping stoves.
The enthalpy change of combustion of propane can be measured by experiment using one of these cylinders.
A known mass of propane is burned to heat a container of water. The temperature rise of the water is measured.

If 0.328 g of propane is burned, the temperature of 100 g water increases from 19.5 °C to 43.0 °C.

(b) (i) Using these results, calculate the experimental value for $\Delta_c H(C_3H_8(g))$.
The specific heat capacity of water is 4.18 J $g^{-1}$ °$C^{-1}$.
$M(C_3H_8)$ = 44.0 g $mol^{-1}$.

(ii) The results of this experiment are inaccurate due to heat loss.
Suggest **one** other source of error, other than measurement errors and limitations of the equipment.

(c) Calcium chloride, $CaCl_2$ can be formed by burning calcium metal in chlorine gas.

$$Ca(s) + Cl_2(g) \rightarrow CaCl_2(s); \Delta_r H^o = -796 \text{ kJ mol}^{-1}$$
$$\Delta S^o_{system} = -101.8 \text{ J mol}^{-1} \text{ K}^{-1}$$
$$\Delta S^o_{surroundings} = +2670 \text{ J mol}^{-1} \text{ K}^{-1}$$

(i) Explain fully why the standard entropy change of the system $\Delta S^o_{system}$ has a negative value.

(ii) Explain fully why you would expect the standard entropy change of the surroundings $\Delta S^o_{surroundings}$, to have a positive value.

(iii) The total entropy change, $\Delta S^o_{total}$ can be calculated by using the following equation:

$$\Delta S^o_{total} = \Delta S^o_{surroundings} + \Delta S^o_{system}$$

The total entropy change for this reaction is:

$$+2670 + (-101.8) = +2568.2 = +2570 \text{ J mol}^{-1} \text{ K}^{-1} \text{ (3 s.f.)}$$

What does $\Delta S^o_{total}$ tell you about the spontaneity of this reaction?

**Extra paper if required.**

**Write the question number(s) if applicable**