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Level 3 Chemistry 2021

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.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table and other reference material are provided in the Resource Booklet L3–CHEMR.

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

Check that this booklet has pages 2 – 12 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (▨). This area may be cut off when the booklet is marked.

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

QUESTION ONE

(a) Complete the following table.

Symbol	Electron configuration (use *s*, *p*, *d* notation)
Sc	
Ga	
Fe^{3+}	

(b) (i) Complete the table below.

	SeF_4	**ClF_4^-**
Lewis structure		
Name of shape		

(ii) Both $\Delta_{vap}H°(SeF_4)$ and $\Delta_{fus}H°(SeF_4)$ are positive.

Explain why $\Delta_{vap}H°(SeF_4)$ is more positive.

(c) Potassium nitrate, KNO_3, readily dissolves in water according to the equation below:

$KNO_3(s) \rightarrow K^+(aq) + NO_3^-(aq)$ $\Delta_r H° = +34.9$ kJ mol^{-1}

(i) Justify, in terms of the entropy changes of the system and the surroundings, why the reaction is spontaneous.

(ii) When solid KNO_3 dissolves in water, the temperature decreases from 21.3 °C to 14.2 °C.

Calculate the mass of solid KNO_3 that must dissolve to cause this temperature decrease.

Assume the specific heat capacity of potassium nitrate solution is 4.18 J g^{-1} °C^{-1}.

Assume the mass of the potassium nitrate solution is 135 g.

$M(KNO_3) = 101$ g mol^{-1}

QUESTION TWO

(a) Explain the difference in the atomic radii of calcium and selenium.

	Atomic radius / pm
Calcium, Ca	197
Selenium, Se	116

(b) Justify, with reference to the factors affecting periodic trends, why fluorine is the most electronegative element in Group 17.

(c) (i) The equation for the reaction of ammonia, NH_3, with oxygen, O_2, is given below:

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

Calculate the standard enthalpy change for this reaction, $\Delta_r H°$, using the following data:

$2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$ $\quad \Delta_r H° = +92$ kJ mol^{-1}

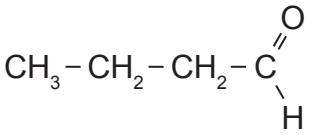
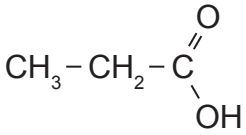
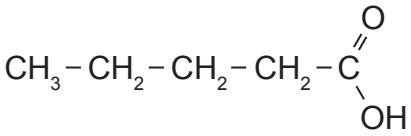
$2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$ $\quad \Delta_r H° = +572$ kJ mol^{-1}

$N_2(g) + O_2(g) \rightarrow 2NO(g)$ $\quad \Delta_r H° = +180$ kJ mol^{-1}

(ii) Explain why the standard enthalpy change calculated in part (i) would be more exothermic if the water was produced as a liquid.

QUESTION THREE

(a) (i) Identify all the types of attractive forces between the particles of the following substances in their liquid state.

Substance	$\Delta_{vap}H°$ / kJ mol^{-1}	Attractive forces
Butanal (ℓ) 	34	
Propanoic acid (ℓ) 	57	
Pentanoic acid (ℓ) 	68	

(ii) With reference to the relative strength of all the attractive forces between the particles in each substance, justify the difference in standard enthalpy of vaporisation, $\Delta_{vap}H°$, for butanal, propanoic acid, and pentanoic acid.

(b) (i) Write the equation for the reaction that has an enthalpy change equal to the standard enthalpy of formation, $\Delta_f H°$, of solid glucose, $C_6H_{12}O_6(s)$.

(ii) Glucose is oxidised during aerobic respiration according to the following equation:

$$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(\ell) \quad \Delta_r H° = -2803 \text{ kJ mol}^{-1}$$

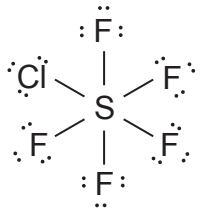
Calculate the standard enthalpy of formation of glucose, $\Delta_f H°(C_6H_{12}O_6(s))$, using the following data:

$\Delta_f H°(CO_2(g)) = -394 \text{ kJ mol}^{-1}$

$\Delta_f H°(H_2O(\ell)) = -286 \text{ kJ mol}^{-1}$

Question Three continues on the next page.

(c) The Lewis structure for chloropentafluorosulfane, $SClF_5$, is given below:



Identify and explain the shape and polarity of $SClF_5$.

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