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CHEMISTRY

Physical Chemistry

Level & Board	AQA (A-LEVEL)
TOPIC:	ENERGETICS
PAPER TYPE:	SOLUTION - 3
TOTAL QUESTIONS	10
TOTAL MARKS	44

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Energetics - 3

1.

(a)

i.

It represents the energy released or absorbed during the combustion of one mole of a substance and is typically measured in kilojoules per mole (kJ/mol).

The standard enthalpy of combustion, denoted as ΔH°_c , is the enthalpy change that occurs when one mole of a substance (or compound) reacts completely with oxygen (or burned in excess oxygen) at a temperature of 298 K (25 °C) and a pressure of 100 kPa (or 1 bar) under standard conditions.

(2)

ii.

Given:

Mass of methanol burned = 2.12 g

Mass of water heated = 150 g

Initial temperature of water = 298 K

Final temperature of water = 362 K

Specific heat capacity of water = $4.18 \text{ J K}^{-1} \text{ g}^{-1}$

Calculate the energy absorbed by the water:

$$Q = mc\Delta T$$

$$Q = 150 \text{ g} \times 4.18 \text{ J K}^{-1} \text{ g}^{-1} \times (362 \text{ K} - 298 \text{ K})$$

$$Q = 39816 \text{ J}$$

Convert the mass of methanol burned to moles: Number of moles of

methanol burned = Mass of methanol burned / Molar mass of methanol

$$\text{Number of moles of methanol burned} = 2.12 \text{ g} / 32.04 \text{ g/mol}$$

$$= 0.066 \text{ moles}$$

Calculate the enthalpy change per mole of methanol:

Enthalpy change per mole of methanol

$$= \text{Energy released by burning methanol} / \text{Number of moles of methanol burned}$$

$$= 39816 \text{ J} / 0.066 \text{ moles}$$

$$= 603090 \text{ J/mol}$$

$$= 603.09 \text{ kJ/mol}$$

(5)

(b)

$$\Delta H^{\circ}_c(\text{CH}_3\text{OH}) = \Delta H^{\circ}_c(\text{CO}) + 2 \times \Delta H^{\circ}_c(\text{H}_2) - \Delta H_1$$

Given:

$$\Delta H^{\circ}_c(\text{CO}) = -283 \text{ kJ/mol}$$

$$\Delta H^{\circ}_c(\text{H}_2) = -91 \text{ kJ/mol}$$

Substitute the values:

$$\begin{aligned} \Delta H^{\circ}_c(\text{CH}_3\text{OH}) &= \Delta H^{\circ}_c(\text{CO}) + 2 \times \Delta H^{\circ}_c(\text{H}_2) - \Delta H_1 \\ &= (-283) + (2 \times (-286)) - (-91) \end{aligned}$$

$$\Delta H^{\circ}_c(\text{CH}_3\text{OH}) = (-283) + (2 \times (-286)) - (-91)$$

$$\Delta H^{\circ}_c(\text{CH}_3\text{OH}) = -283 - 572 + 91$$

$$\Delta H^{\circ}_c(\text{CH}_3\text{OH}) = -855 + 91$$

$$\Delta H^{\circ}_c(\text{CH}_3\text{OH}) = -764 \text{ kJ/mol}$$

(3)

2.

The standard enthalpy of hydration is the amount of heat energy released or absorbed when one mole of gaseous ions dissolves in water to form an aqueous solution under standard conditions, which typically include a temperature of 25 °C (298 K) and a pressure of 1 atmosphere.

(2)

3. (D)

(1)

4. (D)

(1)

5.

(a)

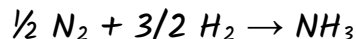
The term "mean bond enthalpy" refers to the average energy required to break a covalent bond, also known as the bond enthalpy.

This value represents an average because the energy needed to break a specific bond can vary across different compounds. It is determined by averaging the dissociation energies of a particular bond across various molecules containing that bond.

(2)

(b)

i.



(2)

ii.

$$\begin{aligned} \Delta H &= (\Sigma) \text{bonds broken} - (\Sigma) \text{bonds formed} \\ &= \frac{1}{2} \times 944 + \frac{3}{2} \times 436 - 3 \times 388 \\ &= -38 \text{ kJ mol}^{-1} \end{aligned}$$

(2)

(c)

$$\begin{aligned} \Delta H &= (\Sigma) \text{bonds broken} - (\Sigma) \text{bonds formed} \\ 4(\text{C-H}) + (\text{C}=\text{C}) + (\text{H-H}) - (6(\text{C-H}) + (\text{C-C})) &= -136 \\ (\text{C}=\text{C}) + (\text{H-H}) - ((\text{C-C}) + 2(\text{C-H})) &= -136 \\ 2(\text{C-H}) &= 836 \\ (\text{C-H}) &= 418 \text{ (kJ mol}^{-1}\text{)} \end{aligned}$$

(3)

6.

Given:

Mass of methane burned = 0.10 g

Molar mass of methane (CH_4) = 12.01 g/mol $(\text{C}) + 4(1.01 \text{ g/mol})$ $(\text{H}) = 16.05 \text{ g/mol}$

Number of moles of methane burned = Mass of methane burned / Molar mass of methane

$$= 0.10 \text{ g} / 16.05 \text{ g/mol}$$

$$= 0.00624 \text{ moles}$$

The standard enthalpy of combustion of methane is given as -890 kJ/mol

Energy released = moles of methane burned \times Enthalpy of combustion

$$\text{Energy released} = 0.00624 \text{ moles} \times (-890 \text{ kJ/mol})$$

$$\text{Energy released} = -5.5656 \text{ kJ}$$

This energy, -5.5656 kJ, will be transferred to the vessel and its contents

The total heat capacity is 120 J/K.

So,

$$Q (\text{energy}) = (mc) \Delta T$$

Change in Temperature = Energy / heat capacity

$$= 5565.6 \text{ J} / 120 \text{ J/K}$$

$$= 46.38 \text{ K}$$

(4)

7.

(a) The standard molar enthalpy of formation (ΔH_f°) is the heat change when one mole of a compound forms from its elements in their standard states at 298 K and 1 atm pressure. It measures the energy released or absorbed during the formation of a compound and is expressed in kilojoules per mole (kJ/mol).

(2)

(b)

Hess's Law states that the total enthalpy change of a chemical reaction is independent of the pathway between the initial and final states.

In other words, the overall enthalpy change for a reaction depends only on the initial and final states of the system, not on the intermediate steps taken.

For a chemical reaction $A \rightarrow B$, the change in enthalpy (ΔH) can be expressed as the difference between the sum of enthalpies of formation of products (B) and the sum of enthalpies of formation of reactants (A):

$$\Delta H = \sum \Delta H_f(\text{products}) - \sum \Delta H_f(\text{reactants})$$

This principle allows for the calculation of the total enthalpy change of a reaction by using the known enthalpy changes of individual steps or other related reactions, regardless of the route taken.

(1)

8.

Mean Bond Enthalpy:

Average energy needed to break a specific type of bond in different molecules.

Standard Enthalpy of Formation:

Heat energy change when one mole of a compound forms from its elements in their standard states.

(2)

9.

(a)

Given enthalpy of formation data:

$$\Delta H_f^\circ(\text{V}_2\text{O}_5) = -1560 \text{ kJ/mol}$$

$$\Delta H_f^\circ(\text{CaO}) = -635 \text{ kJ/mol}$$

First, let's sum up the enthalpies of formation for the products and reactants:

Reactants: $5\Delta H_f^\circ(\text{Ca}) + \Delta H_f^\circ(\text{V}_2\text{O}_5)$

Products: $2\Delta H_f^\circ(\text{V}) + 5\Delta H_f^\circ(\text{CaO})$

Now, substitute the given values into these expressions:

Reactants:

$$5 \times 0 \text{ kJ/mol} + (-1560 \text{ kJ/mol}) = -1560 \text{ kJ/mol}$$

Products:

$$2 \times 0 \text{ kJ/mol} + 5 \times (-635 \text{ kJ/mol}) = -3175 \text{ kJ/mol}$$

Hess's Law:

$$\Delta H = \Sigma \Delta H_f (\text{products}) - \Sigma \Delta H_f (\text{reactants})$$

$$\Delta H^\circ = -3175 \text{ kJ/mol} - (-1560 \text{ kJ/mol})$$

$$\Delta H^\circ = -3175 \text{ kJ/mol} + 1560 \text{ kJ/mol}$$

$$\Delta H^\circ = -1615 \text{ kJ/mol}$$

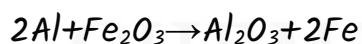
The type of reaction undergone by V_2O_5 is reduction or redox.

One major reason for the expense of extraction, aside from heating the reaction mixture, could be the costliness of calcium production, which often involves energy-intensive processes like electrolysis or requires substantial energy usage due to the high reactivity of calcium metal.

(5)

(b)

The balanced chemical equation for this reaction is:

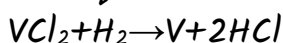


In this reaction, the oxidation state of aluminum changes from 0 to +3. Aluminum goes from being in its elemental state (oxidation state of 0) to being part of the compound aluminum oxide (Al_2O_3), where aluminum exhibits an oxidation state of +3.

(2)

(c)

The equation for the reaction of hydrogen with vanadium(II) chloride is:



Hazards in this process:

Hydrogen Chloride (HCl) Toxicity: HCl is corrosive, acidic, and toxic upon exposure, posing health risks to skin, eyes, and the respiratory system.

Hydrogen (H₂) Flammability: Hydrogen gas is highly flammable, posing a risk of fire or explosion when exposed to air in certain conditions.

For obtaining pure vanadium:

The reason this process yields pure vanadium is that HCl is easily removed from the reaction system.

Hydrogen chloride gas (HCl) is a byproduct in the gaseous state, which can be easily separated or removed from the system due to its gaseous nature.

This leaves behind pure vanadium metal, as it is the only solid product obtained from the reaction, allowing for straightforward separation from the gaseous byproduct.

(4)

10. (c)

(1)

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I am Sorry !!!!!



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- Founder & CEO of Chemistry Online Tuition Ltd.
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