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VCE Chemistry $\frac{3}{4}$
Gas Calculations & Stoichiometry [1.3]
Homework

Homework Outline:

| | |
|-------------------------|---------------|
| Compulsory Questions | Pg 2 – Pg 12 |
| Supplementary Questions | Pg 13 – Pg 24 |



Section A: Compulsory Questions (56 Marks)

Sub-Section: Identify Changes to Minimise Heat Loss & Calculate Percentage Efficiency



Question 1 (2 marks)



An experiment involves a propane canister containing 3.00 g of propane.

- a. Assuming an excess supply of oxygen, calculate the amount of energy released in kJ if the molar heat of combustion of propane is $-2220 \text{ kJ mol}^{-1}$. (1 mark)

- b. Later, 1.50 g of methanol was combusted, given that the molar heat of combustion is -726 kJ mol^{-1} . Calculate the amount of energy released during the combustion of methanol. (1 mark)

Question 2 (4 marks)



A sample of ethanol in a spirit burner initially weighs 120.50 g. After complete combustion, the spirit burner weighs 115.30 g. The heat released is used to heat 500 mL of water at SLC. The temperature of the water rises from 25.00 °C to 60.50 °C.

- a. Calculate the heat of combustion of ethanol in $kJ \text{ mol}^{-1}$. Take the specific heat capacity of water to be $4.18 \text{ J g}^{-1} \text{ °C}^{-1}$. (3 marks)

- b. What is the efficiency of the experiment? Given that the heat of combustion of ethanol is known to be $-1370 \text{ kJ mol}^{-1}$. (1 mark)

Question 3 (4 marks)


A sample of methanol in a spirit burner initially weighs 55.50 g . After complete combustion, the spirit burner weighs 53.50 g . The heat energy released is used to heat 400 mL of water at SLC. The temperature rises to 45.00°C .

- a. Calculate the heat of combustion of methanol in kJ mol^{-1} and calculate the energy efficiency of this experiment. (3 marks)

- b. Suggest a method to improve the efficiency of the spirit burner and minimise heat loss. (1 mark)

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Sub-Section: Apply to Calculate Volumes of Gas at SLC

Question 4 (2 marks)



For the following scenarios, assume everything occurs at SLC.

- a. Find the amount, in moles, of 3.00 L of methane gas. (1 mark)

- b. Find the volume that 15.00 g of nitrogen dioxide occupies. (1 mark)

Question 5 (3 marks)



A sample of 15.2 g of butane is being investigated.

- a. Determine the volume that this butane will occupy at SLC. (1 mark)

- b. Another sample of hydrogen gas weighing 61.9 g is also added to the butane. Determine the volume that the mixture of both gases will occupy at SLC. (2 marks)

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Question 6 (6 marks)

A gas canister containing 25.0 L of butane is used in a conventional barbeque.

- a. Calculate the amount of energy that will be released, given the entire gas canister undergoes complete combustion at SLC. (2 marks)

- b. A 50.0 L canister is filled half with liquid butane that has a density of 0.888 g L^{-1} . The other half of the canister is filled with the same gaseous butane. Calculate the potential amount of energy if all the liquid and gas butane underwent combustion. (2 marks)

- c. If the reaction occurred at 100°C instead, what would the answer to **part a.** be? (2 marks)

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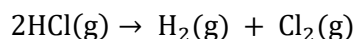


Sub-Section: Apply m - m, m - v, v - v Stoichiometry to Calculation Questions with Equations

Question 7 (2 marks)



The following equation is used for the production of chlorine gas:

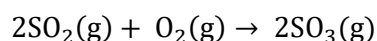


Given that 10.0 g of HCl(g) has reacted, calculate the volume of gases that are produced at SLC.

Question 8 (5 marks)



At high temperatures in industrial processes, sulfur dioxide reacts with oxygen to produce sulfur trioxide, as shown by the equation:



- a. Assuming the temperature and volume are constant, if 50 mL of sulfur dioxide is reacted, what is the volume of oxygen required to produce sulfur trioxide? (2 marks)

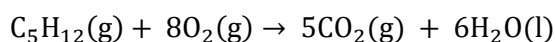
- b. What is the initial volume of reactants in this reaction? (1 mark)

- c. What is the final volume of products in this reaction? (1 mark)

- d. Is there an overall increase or decrease in the volume of gases upon completion of the reaction? (1 mark)

Question 9 (4 marks)


Pentane undergoes combustion occurring to the reaction below:



10.5 g of pentane undergoes complete combustion at SLC.

- a. Determine the minimum amount (in *mol*) of oxygen gas required to ensure that complete combustion occurs. (2 marks)

- b. Calculate the total volume of carbon dioxide that is produced because of complete combustion of 10.5 g of pentane at SLC. (2 marks)

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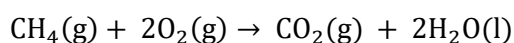


Sub-Section: Identify Limiting Reagents

Question 10 (2 marks)



Methane reacts with oxygen gas according to the following equation:

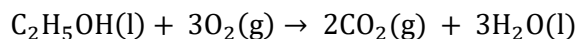


A mixture contains 5.0 g of methane and 12.0 L of oxygen gas at SLC. Determine the excess and limiting reagent.

Question 11 (5 marks)



Ethanol undergoes complete combustion according to the following equation:



10.0 g of ethanol is mixed with 15.0 L of oxygen gas at SLC.

a. Find the limiting reagent. (2 marks)

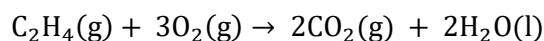
b. Calculate the mass of carbon dioxide produced. (1 mark)

- c. Calculate the mass of the excess reagent leftover. (2 marks)

Question 12 (7 marks)



Ethene undergoes complete combustion according to the following equation:



4.0 g of ethene reacts with 12.0 L of oxygen gas at SLC.

- a. Determine the limiting reagent. (2 marks)

- b. Calculate the total number of moles of products formed. (2 marks)

- c. Given the reaction occurs according to the above, what is the mass of the excess reagent at the end? (2 marks)

- d. Calculate the volume of carbon dioxide produced at SLC. (1 mark)

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Sub-Section: Final Boss

Question 13 (10 marks)



Jet fuel is mostly comprised of kerosene which is a mixture of different hydrocarbons of differing carbon chain lengths ($C_{12}H_{26}$ – $C_{15}H_{32}$).

The jet fuel of two different airlines were compared to one another to see the differences.

Fuel A - 20% ($C_{12}H_{26}$ – $C_{13}H_{28}$) and 80% ($C_{14}H_{30}$ – $C_{15}H_{32}$).

Fuel B - 80% ($C_{12}H_{26}$ – $C_{13}H_{28}$) and 20% ($C_{14}H_{30}$ – $C_{15}H_{32}$).

20.0 L of each fuel were compared to one another.

- a. Given that Fuel B has an average molar heat of combustion of 4290 kJ mol^{-1} , calculate the amount of energy released by the complete combustion of 20.0 L of Fuel B at SLC. (2 marks)

- b. Explain whether Fuel A or Fuel B will produce more energy upon complete combustion. (2 marks)

- c. It is known that Fuel A is more likely to undergo incomplete combustion. Explain a potential reason for this observation using your knowledge of thermochemistry. (2 marks)

- d. Explain whether Fuel *A* or Fuel *B* is more likely to release more carbon dioxide gas, for the same amount of moles combusted. (2 marks)

- e. Based on your answer to **part d.**, can the same be said for the same energy being produced? (2 marks)

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Section B: Supplementary Questions (69 Marks)

Sub-Section: Identify Changes to Minimise Heat Loss & Calculate Percentage Efficiency



Question 14 (2 marks)



An experiment involves a butane canister containing 5.00 g of butane.

- a. Assuming excess oxygen, what is the amount of energy released in kJ if the molar heat of the combustion of butane is $-2880 \text{ kJ mol}^{-1}$. (1 mark)

- b. Later 2.00 g of ethanol was combusted, given that the molar heat of combustion of ethanol is $-1370 \text{ kJ mol}^{-1}$, calculate the amount of energy released during its combustion. (1 mark)

Question 15 (3 marks)



A sample of propanol in a spirit burner initially weighs 95.80 g. After complete combustion, the spirit burner weighs 93.45 g. The heat energy released is used to heat 400 mL of water at SLC. The temperature of the water rises 22.00 °C to 48.50°C.

Calculate the heat of combustion of propanol in kJ mol^{-1} .

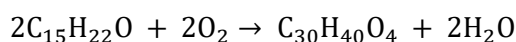
Question 16 (3 marks)


A sample of ethanol in a spirit burner initially weighs 60.00 g. After complete combustion, the spirit burner weighs 50.50 g. The heat energy released is used to heat 500 mL of water at SLC. The temperature of the water rises from 25.00 °C to 60.00 °C.

Calculate the heat of combustion of ethanol in kJ mol^{-1} and state its energy efficiency.

Question 17 (6 marks)


In the pharmaceutical industry, there is a particular compound that is highly desired. Its production involves a two-step process, whereby an intermediate product ($\text{C}_{15}\text{H}_{22}\text{O}$) is first produced, and then converted into the final product ($\text{C}_{30}\text{H}_{40}\text{O}_4$). The final product is produced via the following reaction:



- a. Given 10.0 mol of $\text{C}_{15}\text{H}_{22}\text{O}$ is reacted, calculate the final amount in grams of $\text{C}_{30}\text{H}_{40}\text{O}_4$ produced. (2 marks)

b. In practice, both reactions are 75% efficient.

- i.** Hence, calculate the amount of *mol* of $C_{30}H_{40}O_4$ that will be produced given 10.0 *mol* of $C_{15}H_{22}O$ is reacted. (2 marks)

- ii.** Using your response to the previous question, explain whether in practice the final *mol*, or the final mass of $C_{30}H_{40}O_4$ will be affected. (2 marks)

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Sub-Section: Apply to Calculate Volumes of Gas at SLC

Question 18 (2 marks)



For the following scenario, assume everything occurs at SLC.

- a. Find the amount, in *mol*, of 6.00 L of ammonia gas, NH_3 . (1 mark)

- b. Find the volume that 10.00 g of sulfur dioxide occupies. (1 mark)

Question 19 (3 marks)



A sample of 20.5 g of propane is being investigated.

- a. Determine the volume that propane will occupy at SLC. (1 mark)

- b. Another sample of oxygen gas weighing 96.0 g is also added to the propane. Determine the volume that the mixture of both gases will occupy at SLC. (2 marks)

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Question 20 (4 marks)


A gas canister containing 30.0 L of methane is used in a portable stove.

- a. Calculate the amount of energy that will be released given the entire gas canister undergo complete combustion at SLC. (2 marks)

- b. The same 30.0 L canister is filled half with liquid methane that has a density of 0.415 g L^{-1} . The other half of the canister is filled with gaseous methane. Calculate the potential amount of energy, if all the liquid and gas methane underwent combustion. (2 marks)

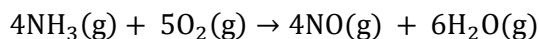
Question 21 (6 marks)


Ammonia gas (NH_3) is a versatile compound used as a fertiliser in agriculture, a key ingredient in nitric acid production, and a refrigerant. Its applications extend to pharmaceutical synthesis and cleaning agents. Despite its pungent odour and toxicity, ammonia gas plays a key role in agriculture, industry and various industrial process.

- a. Calculate the volume that a sample of 20.0 g of ammonia gas (NH_3) will occupy at SLC. (1 mark)

- b. Determine the volume that 15.70 mol of ammonia gas will occupy at SLC. (1 mark)

c. Now, consider the reaction involving ammonia that occurs at SLC:



- i. If there was 12.50 L of ammonia that reacts, calculate the total mass of products made. (3 marks)

- ii. What type of data would you need if the reaction was not at SLC to convert from volume to moles? (1 mark)

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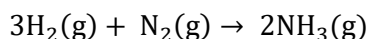


Sub-Section: Apply m - m, m - v, v - v Stoichiometry to Calculation Questions with Equations

Question 22 (3 marks)



Hydrogen gas reacts with nitrogen gas to produce ammonia, as represented by the equation:



If 12.0 L of hydrogen gas reacts completely with nitrogen gas at SLC,

- a. What volume of nitrogen gas is required? (1 mark)

- b. What volume of ammonia is produced? (2 marks)

Question 23 (3 marks)



The decomposition of potassium chlorate produces oxygen gas:

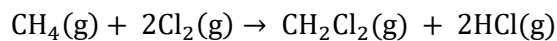


- a. How many moles of oxygen gas are produced when 5.00 g of potassium chlorate decomposes? (2 marks)

- b. Calculate the total volume of oxygen gas produced at SLC. (1 mark)


Question 24 (5 marks)

Methane reacts with chlorine gas to produce dichloromethane and hydrochloric acid according to the following equation:



- a. If 2.50 g of methane reacts, what is the mass of chlorine gas required? (2 marks)

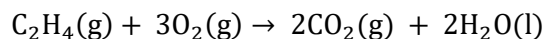
- b. Calculate the total volume of gases produced in the reaction if the reaction occurs at SLC. (2 marks)

- c. Determine the total number of molecules of hydrochloric acid produced. (1 mark)

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Question 25 (7 marks)

Ethene combusts in oxygen to produce carbon dioxide and water: Two experiments were completed using this reaction:



a. The first experiment used 4.50 g of ethene.

i. If the ethene is combusted completely, determine the moles of oxygen gas required. (2 marks)

ii. Calculate the total volume of reactants consumed at SLC. (2 marks)

iii. What volume of carbon dioxide is produced at SLC? (1 marks)

b. The second experiment used 4.50 L of ethene:

Now, determine the volume of carbon dioxide gas produced at SLC. (2 marks)

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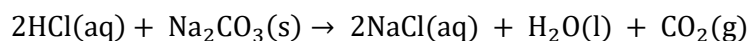


Sub-Section: Identify Limiting Reagents

Question 26 (2 marks)



Hydrochloric acid reacts with sodium carbonate according to the following equation:



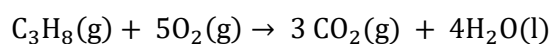
A reaction is set up using 7.30 g of sodium carbonate and 1.0 L of 0.05 M hydrochloric acid.

Determine the excess and limiting reagent.

Question 27 (5 marks)



Propane undergoes complete combustion according to the following equation:



8.8 g of propane reacts with 25.0 L of oxygen gas at SLC.

a. Find the limiting reagent. (2 marks)

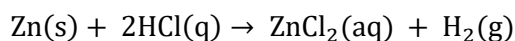
b. Calculate the mass of carbon dioxide produced. (1 mark)

- c. Calculate the mass of the excess reagent left over. (2 marks)

Question 28 (7 marks)



Zinc reacts with hydrochloric acid according to the following equation:



A reaction is carried out by mixing 6.50 g of zinc with 120.0 mL of 2.0 M hydrochloric acid.

- a. Determine the limiting reagent. (2 marks)

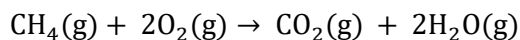
- b. Calculate the total volume of gases produced in the reaction if the reaction occurs at SLC. (2 marks)

- c. Determine the total volume of hydrogen gas produced. (1 mark)

- d. Calculate the mass of the excess reagent left over. (2 marks)


Question 29 (8 marks)

Given the following reaction:



A sample of 8.00 L of methane is mixed with 20.0 L of oxygen gas at SLC.

- a.** Identify the excess and limiting reagent. (3 marks)

- b.** Calculate the mass, in g, of excess reagent left unreacted. (2 marks)

- c.** Determine the total volume of carbon dioxide gas produced at SLC. (1 mark)

- d.** Suppose the reaction occurs with the prescribed amounts, then what is the total volume of gas left over at the end, assuming that the water is completely converted to gas at the end? (2 marks)

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