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# VCE Chemistry ¾
## Gas Calculations & Stoichiometry [1.3]
## Homework Solutions

### Homework Outline:

## 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 $-2220\ kJ\ mol^{-1}$. (1 mark)

$3/(12 \times 3) + 8 = 0.068$ moles $\times\ 2220 = 151.36\ kJ$

**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)

$1.50/32 = 0.046875 \times 726 = 34.03\ kJ$

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

Mass of fuel $= 120.50 - 115.30 = 5.2\ g/46 = 0.113$ moles

$Q = 500 \times 4.18 \times 35.5 = 74195\ J = 74.2\ kJ$

$74.2\ kJ/0.113 = 656\ kJ\ mol^{-1}$

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

$656/1370 \times 100 = 47.88\%$

**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)

$55.50 - 53.50 = 2.00\ g$

Methanol $= 32\ g\ mol \rightarrow 2.00/32 = 0.063\ mol$

Q $= 400 \text{ x } 4.18 \text{ x } 23 = 38{,}26\ kJ \rightarrow 38.26/0.063 = 607.3\ kJ\ mol^{-1}$

$607.3/726 \rightarrow 100 = 83.65\%$ efficient.

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

Put a lid on heat, use a heat deflector (aluminium foil screen) to prevent heat loss, etc.

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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)

$3/24.8 = 0.12096$ moles

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

$15/14 + 32 = 0.326$ moles $\times 24.8 = 8.087\ L$

**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)

$n(C_4H_{10}) = 15.2/12 \times 4 + 10 = 0.262$ moles

$0.262 \times 24.8 = 6.50\ L$

**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)

$n(H_2) = 61.9 / 2 = 30.95$ moles

$30.95 + 0.262 = 31.212$ moles

$31.212 \times 24.8 = 774.0576\ L = 774\ L$

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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)

$$\text{n(butane)} = 25/24.8 = 1.008 \text{ moles}$$
$$2880 \times 1.008 = 2.90 \times 103\ kJ$$

**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)

$$0.888 \times 25 = 22.2\ g \rightarrow 22.2/58 \rightarrow 0.3827 \text{ moles} \rightarrow 0.3827 \times 2880 = 1102\ kJ$$

From (a)$\rightarrow$ $2.90 \times 103/2 = 1450\ kJ$ in other half from gas

$$1450 + 1102 = 2552\ kJ$$

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

Wouldn't be able to calculate because it is not at SLC, so cannot convert $L$ to $g$ given the information provided.

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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:

$$2HCl(g) \rightarrow H_2(g) + Cl_2(g)$$

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

n(HCl) = 10/36.5 = 0.27347 moles → same moles as products (conservation of mass)
Volume = 0.27347 × 24.8 = 6.78 $L$

**Question 8** (5 marks)

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

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

**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)

$$V(O_2) = \frac{1}{2}V(SO_2) = \frac{50}{2} = 25 \text{ mL}$$

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

50 + 25 = 75 $mL$

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

2 × 50 mL = 100 $mL$

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

Increase in gas volume.

**Question 9** (4 marks)

Pentane undergoes combustion occurring to the reaction below:

$$C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$$

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)

$$n(C_5H_{12}) = \frac{10.5}{12\times 5+12} = 0.1458 \text{ moles}$$

$$n(O_2) = 0.1458 \times 8 = 1.1667 = 1.17 \text{ moles}$$

**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)

$n(C_5H_{12}) = 0.1458$ moles$\rightarrow$ $0.1457 \times 5 = 0.729$ moles of $CO_2$

$V = 0.729 \times 24.8 = 18.1\ L$

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## Sub-Section: Identify Limiting Reagents

**Question 10** (2 marks)

Methane reacts with oxygen gas according to the following equation:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

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

$5/16 = 0.3125$ moles of methane
$12/24.8 = 0.4838/2 = 0.2419$ moles (1: 1 ratio)
Oxygen gas is the limiting reagent here, whereas methane is the excess reagent.

**Question 11** (5 marks)

Ethanol undergoes complete combustion according to the following equation:

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

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

**a.** Find the limiting reagent. (2 marks)

$10/46 = 0.21739$ moles of ethanol
$15/24.8 = 0.6048$ moles$/3 = 0.2016$
Ethanol is the excess and oxygen gas is the limiting reagent.

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

$0.6048 \times 2/3 = 0.4032$ moles $\times$ 44 $= 17.74\ g$

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

$0.6048 \times 1/3 = 0.2016$ moles needs to react.
$0.21739 - 0.2016 = 0.01579$ moles of ethanol leftover.
$0.01579 \times 46 = 0.726\ g$ ethanol leftover.

**Question 12** (7 marks)

Ethene undergoes complete combustion according to the following equation:

$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$$

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

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

$4/28 = 0.14285$ moles
$12/24.8 = 0.4838$ moles$/3 = 0.16129$ (1:1 ratio)
Ethene is the limiting reagent.

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

$0.14285 \times 2 = 0.2857$ moles of carbon dioxide.
$0.14285 \times 2 = 0.2857$ moles of water.
Total moles $= 0.5714$ moles of products.

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

$0.14285 \times 3 = 0.42855$ moles of oxygen gas reacts.
$0.4838 - 0.42855 = 0.05525$ moles leftover.
$0.05525 \times 32 = 1.768\ g$ of oxygen gas left over.

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

$0.2857 \times 24.8 = 7.08536\ L$

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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)

$$n(B) = V/Vm = 20/24.8 = 0.806 \text{ moles}$$
$$q = 4290 \times 0.806 = 3459.677 = 3.46 \times 10^3\ kJ$$

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

Fuel A- since in 20.0 *L* of both fuel, there will be the same number of *mol*. However, Fuel A contains more long-chained hydrocarbons. As a result, it will produce more energy, since there are more bonds in long-chained hydrocarbons that can release energy.

**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)

Fuel A- Since it contains more long-chained hydrocarbons, these require more oxygen in order to undergo complete combustion. Therefore, in low levels of oxygen, fuel A is more likely to undergo incomplete combustion.

**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)

By stoichiometry, we know that Fuel A will comprise of more long-chained hydrocarbons which means there will be more carbon-based products for Fuel A than Fuel B, meaning that there is more $CO_2$ for the same moles.

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

No, because we know that Fuel A is going to release more energy than fuel B, and we don't know the exact numbers, so it is not possible to tell for $x$ amount of energy which fuel will definitely produce more carbon dioxide gas.

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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 $-2880\ kJ\ mol^{-1}$. (1 mark)

$5/12 \times 4\ +\ 12\ =\ 0.0833$ moles
$0.0833\ \times\ 2880\ =\ 239.904\ kJ$

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

$2.00/46\ =\ 0.0434$ moles
$0.0434 \times\ 1370\ =\ 59.57\ kJ$

**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 $kJ\ mol^{-1}$.

$95.80 - 93.45\ =\ 2.35\ g/36\ +\ 8\ +\ 16\ =\ 0.039167$ moles

$q\ =\ 400 \times\ 4.18\ \times\ (48.50 - 22)\ =\ 44308$ J $=\ 44.308\ kJ$

$44.308/0.039167\ =\ 1131.258\ kJ\ mol^{-1}$

**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.

$60 - 50.50 = 9.50/46 = 0.2065$ moles

$q = 500 \times (60 - 25) \times 4.18 = 73.150\ kJ$

$73.150/0.2065$ moles $= 354.23\ kJ\ mol^{-1}$

$354.23/1370 \times 100 = 25.86\%$

**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 ($C_{15}H_{22}O$) is first produced, and then converted into the final product ($C_{30}H_{40}O_4$). The final product is produced via the following reaction:

$$2C_{15}H_{22}O + 2O_2 \rightarrow C_{30}H_{40}O_4 + 2H_2O$$

**a.** Given 10.0 $mol$ of $C_{15}H_{22}O$ is reacted, calculate the final amount in grams of $C_{30}H_{40}O_4$ produced. (2 marks)

$n(C_{30}H_{40}O_4) = n(C_{15}H_{22}O) \times ½ = 5\ mol$

$5 \times (12 \times 30 + 40 + 16 \times 4) = 2320\ g = 2.32\ kg$

**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)

$n(C_{30}H_{40}O_4) = n(C_{15}H_{22}O) \times ½ = 5\,mol = 5 \times 0.75 = 3.75$ moles

**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)

Mass and $mol$ will be decreased by 25%, multiples of each other and will be affected in the same way.

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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)

$6/24.8 = 0.2419$ moles

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

$10/32.1 + 32 = 0.156$ moles $\times$ $24.8 = 3.869\ L$

**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)

$n(C_3H_8) = 20.5/36 + 8 = 0.359$ moles $\rightarrow$ $0.359 \times 24.8 = 8.91\ L$

**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)

$n(O_2) = 96/32 = 3.00$ moles $\rightarrow$ $3 + 0.359 = 3.359$ moles $\rightarrow$ $3.359 \times 24.8 = 83.4\ L$

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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)

$30/24.8 = 1.2096 \text{ moles} \times 890 = 1076.61\ kJ$

**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)

$15 \times 0.415 = 6.225\ g$ of methane$\rightarrow\ 6.225/16 = 0.389$ moles

$0.389 \times 890 = 346.26\ kJ$

$15/24.8 = 0.6048 \text{ moles} \times 890 = 538.31\ kJ$

Total $= 538.31 + 346.26 = 884.57\ kJ$

**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)

$20/17 = 1.176 \text{ moles} \times 24.8 = 29.18\ L$

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

$15.70 \times 24.8 = 389.36\ L$

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

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

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

$N(C_{30}H_{40}O_4) = n(C_{15}H_{22}O) \times ½ = 5\ mol = 5 \times 0.75 = 3.75$ moles

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

Mass and mol will be decreased by 25%, multiples of each other, and will be affected in the same way.

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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:

$$3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$$

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

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

$12.0/24.8 = 0.4838$ moles $\times\ 1/3 = 0.161$ moles of nitrogen gas
$0.161 \times 24.8 = 4\ L$

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

$0.4838 \times 2/3 = 0.3225$ moles produced
$0.3225 \times 24.8 = 7.99 = 8.00\ L$

**Question 23** (3 marks)

The decomposition of potassium chlorate produces oxygen gas:

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

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

$5/39.1 + 35.5 + 48 = 0.04078$ moles of potassium chlorate
$0.04078 \times 3/2 = 0.06117$ moles of oxygen gas

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

$0.6117 \times 24.8 = 1.517\ L$

**Question 24** (5 marks)

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

$$CH_4(g) + 2Cl_2(g) \rightarrow CH_2Cl_2(g) + 2HCl(g)$$

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

$2.50/16 = 0.15625 \times 2 = 0.3125$ moles of chlorine gas $\times\ 35.5 \times 2 = 22.19\ g$

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

$0.15625 \times 1 = 0.15625$
$0.15625 \times 2 = 0.3125$
Total moles $= 0.46875 \times 24.8 = 11.625\ L$

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

$0.15625 \times 2 = 0.3125$ moles of hydrochloric acid $\times\ 6.02 \times 1023 =$ $1.88 \times 1023$ molecules of HCl

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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:

$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$$

**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)

$4.50/28 = 0.1607$ moles of ethene
$0.1607 \times 3 = 0.482$ moles of oxygen gas

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

$0.482 \times 24.8 = 11.957\ L$
$0.1607 \times 24.8 = 3.99\ L$
Total $= 11.957 + 3.99 = 15.95\ L$

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

$0.1607 \times 2 = 0.3214 \times 24.8 = 7.97\ L$

**b.** The second experiment used 4.50 $L$ of ethene:

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

$4.50/24.8 = 0.18145$ moles
$0.18145 \times 2 = 0.3629 \times 24.8 = 9\ L$

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## Sub-Section: Identify Limiting Reagents

**Question 26** (2 marks)

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

$$2HCl(aq) + Na_2CO_3(s) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

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.

$\frac{7.30}{46+12+36} = 0.077659$ moles of sodium carbonate

$0.05 \times 1 \times \frac{1}{2} = 0.025$ moles of hydrochloric acid (1:1 ratio)

Sodium carbonate is in excess and hydrochloric acid is limiting.

**Question 27** (5 marks)

Propane undergoes complete combustion according to the following equation:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3\,CO_2(g) + 4H_2O(l)$$

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

**a.** Find the limiting reagent. (2 marks)

$\frac{8.8}{44} = 0.2$ moles of propane

$\frac{25.0}{24.8} \times \frac{1}{5} = 0.2016...$ moles of oxygen gas

Oxygen is in excess and propane is limiting.

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

$0.20 \times 3 = 0.60$ moles $\times$ 44 $=$ 26.40 $g$

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

$0.20 \times 5 = 1.00$ moles
$1.008 - 1.00 = 0.008$ moles leftover$\rightarrow 0.008 \times 32 = 0.256\ g$ leftover

**Question 28** (7 marks)

Zinc reacts with hydrochloric acid according to the following equation:

$$Zn(s) + 2HCl(q) \rightarrow ZnCl_2(aq) + H_2(g)$$

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)

$6.50/65.4 = 0.099$ moles
$0.120 \times 2 = 0.240$ moles$/2\ 0. = 0.120$ (1: 1 ratio)
Zn is limiting reagent.

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

$0.099 \times 65.4 + 35.5 + 35.5 = 13.56\ g$

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

$0.099$ moles $\times 24.8 = 2.46\ L$

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

$0.099 \times 2 = 0.19877$ moles of HCl reacted
$0.240 - 0.19877 = 0.0412$ moles leftover $\times 36.5 = 1.50\ g$ leftover

**Question 29** (8 marks)

Given the following reaction:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

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)

$8/24.8 = 0.3225$ moles of methane
$20/24.8 = 0.8065$ moles of oxygen gas$/2 = 0.403$ moles (1:1 ratio)
Oxygen gas is the excess reagent and methane is the limiting reagent.

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

$0.3225 \times 2 = 0.645$ moles oxygen gas reacted.
$0.8065 - 0.645 = 0.1615$ moles leftover $\times$ 32 $= 5.17\ g$ leftover.

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

$0.3225 \times 24.8 = 7.998\ L \rightarrow 8\ L$

**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)

Leftover oxygen gas $= 0.1615 \times 24.8 = 4.0052\ L$
$CO_2$ gas $= 8\ L$
Water vapour $= 0.3225 \times 2 = 0.645 \times 24.8 = 15.996 = 16\ L$
Total gas $= 4 + 8 + 16 = 28\ L$

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## VCE Chemistry ¾

# Free 1-on-1 Support

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## Booking Link for Consults
## bit.ly/contour-chemistry-consult-2025

## Number for Text-Based Support
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