**Chemistry Module 2 Assignment 3**

**Gas Laws and Enthalpy Changes**

1. a) For a sample of gas, state the relationship between:

* Volume and temperature, for a fixed amount of gas at constant pressure.
* Pressure and volume, for a fixed amount of gas at constant temperature, assuming that the volume of the container remains constant.
* Amount of gas and volume, at constant temperature and pressure
* Pressure and temperature, for a fixed amount of gas at constant volume

(4 marks)

b) Sulfur trioxide, SO3 (g), decomposes into sulfur dioxide gas and oxygen gas according to

the following equation:

2SO3 (g) → 2SO2 (g) + O2 (g)

Assuming the reaction goes to completion explain why, when this reaction takes place

at constant pressure and temperature, the volume of the product gases is 50% larger

than the original volume of SO3. (2 marks)

c) A container is filled with an ideal gas to a pressure of 15.0 atm at 0°C.

i) What will be the pressure in the container if it is heated to 55°C?

ii) At what temperature would the pressure be 8.50 atm?

iii) If the volume of the container doubles and the temperature is raised by 25°C,

what will the new pressure be?

(6 marks)

2. The inﬂation of an air bag during a car crash is due to production of nitrogen gas, N2(g), by

the following reaction:

2NaN3(s) → 2Na(s) + 3N2(g)

a) What volume of N2 is produced when 120 g of NaN3 is decomposed during a car crash

at SATP. (3 marks)

b) Quicklime, CaO, is produced by the thermal decomposition of calcium carbonate,

CaCO3. Calculate the volume of CO2 produced from the decomposition of 1.5 kg CaCO3

at SATP by the reaction:

CaCO3(s) → CaO(s) + CO2(g) (3 marks)

*The molar volume of an ideal gas at SATP is 24.8 dm3 mol-1*

3. 1.86 cm3 of a liquid of density 0.803 g cm-3was injected into a syringe maintained at 200°C.

The liquid vapourised completely and occupied 808.54 cm3 at 1.20 atm.

a) Calculate the volume that this sample of vapour will occupy at STP

b) Hence calculate the molar mass of the liquid

(3 marks)

*I mole of an ideal gas occupies 22.4 dm3 at 1.00 atm and 273 K.*

4. a) State Hess’s Law

(1 mark)

b) Deﬁne the Standard Enthalpy Change of Formation of a substance.

(2 marks)

Use the information in the table below to answer the following questions:

|  |  |
| --- | --- |
| Compound | ΔHf / kJ mol-1 |
| NH3 (g) | -46 |
| NO (g) | +90 |
| H2O(l) | -286 |
| CO2 (g) | -393 |
| C6H14 (l) | -199 |
| CH3CH2OH (l) | -278 |

c) i) During the production of nitric acid, NH3 is oxidized to NO and H2O according to

the following equation:

4NH3 (g) + 5O2 (g) → 4NO (g) + 6H2O (l)

Calculate the enthalpy change for this reaction using an energy cycle or any other

appropriate method. (3 marks)

ii) Using your answer to ci) sketch a enthalpy profile diagram for this reaction labelling the

enthalpy of the reactants, the enthalpy of the products and the enthalpy change of the

reaction.

(4 marks)

d) Both ethanol (CH3CH2OH) and hexane (C6H14) are used as fuels.

i) Write thermochemical equations for the enthalpy change of combustion of C6H14 (l) and

CH3CH2OH (l). (2 marks)

ii) Use the information in the table to calculate the enthalpy change of combustion of C6H14(l)

and CH3CH2OH (l). (6 marks)

iii) Calculate how much heat is released when 10 g of C6H14 (l) and CH3CH2OH(l) are burnt.

(4 marks)

5. Given that:

Sn(s) + Cl2 (g) → SnCl2 (s); ΔH = - 350 kJ mol-1

and

Sn (s) + 2Cl2 (g) → SnCl4 (s); ΔH = - 542 kJ mol-1

draw a thermal cycle and calculate the enthalpy change  for

SnCl2 (s) + Cl2 (g) → SnCl4 (s)

You must show your workings to gain credit for this question

(3 marks)

6. This question relates to aqueous solutions of silver(I) nitrate and sodium chloride.

When 1.20 dm3 of 1.00 mol dm-3 AgNO3 solution at 25°C is mixed with 1.20 dm3 of 1.00 mol dm-3 NaCl solution at 25.0°C in a calorimeter, the white solid, AgCl, forms, and the temperature of the solution decreases to 22.1°C.

*For the purpose of your calculations, assume, for the reaction mixture that:*

*specific heat capacity = 4.18 J°C−1g−1 and density = 1.0 g cm−3*

* Write down the net ionic equation for the reaction. (2 mark)
* What is the temperature change? . (1 mark)
* use the values of density and volume of the reaction mixture to calculate the mass of solution that is cooled down during the reaction. (2 marks)
* What is the heat change during the reaction?

(2 marks)

* Calculate the enthalpy change per mole for the reaction.

(2 marks)

7. Calculate ∆H for the reaction of ethane with chlorine and ﬂuorine (below), using the

following mean bond enthalpies shown in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Bond | Mean bond enthalpy/ kJ mol-1 | Bond | Mean bond enthalpy/ kJ mol-1 |
| C-C | 348 | C=O | 743 |
| H-H | 436 | O-H | 463 |
| C=C | 612 | C-Cl | 338 |
| H-Cl | 431 | Cl-Cl | 242 |
| C-H | 413 | C-Br | 276 |
| H-Br | 366 | Br-Br | 193 |
| C-O | 360 | C-F | 485 |
| H-F | 565 | F-F | 154 |

CH3CH3 (g) + 3Cl2 (g) + 3F2 (g) → CF3CCl3 (g) + 3HF (g) + 3HCl (g)

(4 marks)

**Max mark = 60**