

# University of Nottingham

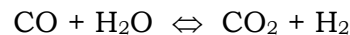
## Department of Mechanical, Materials and Manufacturing engineering

### Thermofluids 3

#### Self Assessment Exercise Sheet – Combustion

1. Methane, CH<sub>4</sub>, is burnt in a steady flow burner with 100% excess air. The mixture enters the burner at 25°C. Combustion may be assumed to be adiabatic and complete (no dissociation). Calculate the temperature of the products in two ways:
- Using mean  $c_p$  taking the enthalpy for the combustion of methane as -50010 kJ/kg (with water in products of combustion as a vapour)
  - Using standardised enthalpy values and taking the standard enthalpy of formation of methane as -74906 kJ/kmol.
- [ (i) 1470 K, (ii) 1481 K ]

2. Using absolute entropy and standardised enthalpy, find the equilibrium constant for the following reaction at 1200K:



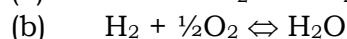
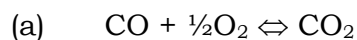
[ 0.733 ]

3. Find the partial pressure of the constituents formed by mixing 0.4 moles of CO and 0.2 moles of H<sub>2</sub>O at 1110K [K = 0.909]. The volume of the mixture is 10 m<sup>3</sup> and the dissociation reaction is the same as in Q2.  
[CO 2.49 bar, H<sub>2</sub>O 0.642 bar, CO<sub>2</sub> 1.205 bar, H<sub>2</sub> 1.205 bar]

4. A fuel equivalent is burnt in air. The products, at 5 bar and 2500 K, gave the following percentage volumetric analysis:

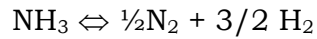
CO <sub>2</sub>	CO	H <sub>2</sub> O	H <sub>2</sub>	O <sub>2</sub>	N <sub>2</sub>
9.74	0.75	11.65	0.15	3.71	74.0

Find the equilibrium constants at 2500 K for the reactions:



[(a) 30.2, (b) 180.3]

5. (a) Ammonia (NH<sub>3</sub>) is produced industrially by the reaction of hydrogen with nitrogen in the proportion 3 volumes of H<sub>2</sub> to 1 volume of N<sub>2</sub>. The dissociation reaction is:



Show that the equilibrium constant,  $K$ , is related to the degree of dissociation,  $\alpha$ , of ammonia by:

$$K = \frac{3\sqrt{3}}{4} \left( \frac{\alpha^2}{1-\alpha^2} \right) \frac{p}{p_0}$$

where  $p$  is the pressure of the gaseous mixture and  $p_0$  is a pressure of 1 bar.

- (b) The change in Gibbs function for the dissociation reaction given in (a) is -23730 kJ/k mole K at 400°C and 1 bar. Calculate the mole fraction of ammonia present in the gaseous mixture at 400°C and 300 bar and at 400°C and 600 bar. Hence deduce whether or not an increase in pressure assists the production of ammonia.

[(b) 0.4399, 0.5551]