Unit 1: Inorganic and physical chemistry Topics 5-7

Please attempt the following questions in preparation for the online session on Tuesday 19th December.

1. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H^o = +57$ kJ mol^{-1}

   Which of the following will increase the equilibrium constant for the reaction?

   A. Use of a catalyst
   B. Increase of pressure
   C. Increase of temperature
   D. Decrease of temperature

2. 1.00 mol of hydrogen iodide was added to a 1 litre flask at 440°C and allowed to dissociate into hydrogen and iodine.

   $$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

   At equilibrium it was found that 0.78 mol of hydrogen iodide were present.

   Calculate the value of the equilibrium constant at this temperature.

3. An acid is a substance which

   A. donates a proton leaving a conjugate acid
   B. donates a proton leaving a conjugate base
   C. accepts a proton leaving a conjugate acid
   D. accepts a proton leaving a conjugate base.

4. Methanoic acid is a weak acid.

$$HCOOH(aq) + H_2O(l) \rightleftharpoons HCOO^-(aq) + H_3O^+(aq)$$

(a) State the conjugate base of methanoic acid.

(b) Write the expression for the dissociation constant, K_a, of methanoic acid.

(c) When an ant bites, it injects methanoic acid. In a typical bite, 3.6×10^{-3} g of methanoic acid is injected. Assuming that the methanoic acid dissolves in 1.0 cm^3 of water in the body, calculate the pH of the resulting methanoic acid solution.

5. To determine the concentration of ethanoic acid in a sample of vinegar, a student titrated the vinegar with sodium hydroxide solution. A suitable indicator which could be used in this titration is

A. screened methyl orange
B. bromophenol blue
C. phenolphthalein
D. methyl red.

6. Which of the following when added to aqueous NH_4Cl can produce a buffer solution?

A. Ammonia
B. Ethanoic acid
C. Potassium chloride
D. Ammonium sulfate

7. A buffer solution was made by dissolving 2.24 g of potassium propanoate, C_2H_5COOK, in 250 cm^3 0.20 mol l^{-1} propanoic acid.

   Calculate the pH of this buffer solution.

8. Which of the following reactions results in a decrease in entropy?

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

   B. $N_2O_4(g) \rightarrow 2NO_2(g)$

   C. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

   D. $C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$

9. The reaction taking place in a methanol fuel cell is

   $CH_3OH(l) + 1½O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \quad \Delta H^o = -727 \text{ kJ mol}^{-1}$

Substance	S^o/J K^{-1} mol^{-1}
$CH_3OH(l)$	127.0
$O_2(g)$	205.2
$CO_2(g)$	213.8
$H_2O(l)$	69.9

   (a) Calculate the entropy change, ΔS^o, in J K^{-1} mol^{-1} for the reaction.

   (b) Calculate the standard free energy change, ΔG^o, in kJ mol^{-1} for the reaction.

10. For the reaction

$$NO(g) + N_2O_5(g) \rightarrow 3NO_2(g)$$

the following mechanism is suggested.

Step 1 $N_2O_5(g) \rightarrow NO_2(g) + NO_3(g)$ slow
Step 2 $NO(g) + NO_3(g) \rightarrow 2NO_2(g)$ fast

Experimental evidence to support this would be obtained if the rate of the reaction equals

A. $k[N_2O_5]$
B. $k[NO]$
C. $k[NO][NO_3]$
D. $k[N_2O_5][NO]$.

11. The following results were obtained for the reaction below.

$$H_2O_2(aq) + 2HI(aq) \rightarrow 2H_2O(l) + I_2(aq)$$

Experiment	$[H_2O_2]$/mol l^{-1}	[HI]/mol l^{-1}	Initial Rate/mol $l^{-1}s^{-1}$
1	3.2×10^{-4}	4.1×10^{-4}	4.3×10^{-9}
2	6.4×10^{-4}	4.1×10^{-4}	8.6×10^{-9}
3	3.2×10^{-4}	8.2×10^{-4}	8.6×10^{-9}
4	6.4×10^{-4}	8.2×10^{-4}	1.72×10^{-8}

(a) Determine the order of this reaction with respect to

(i) H_2O_2
(ii) HI.

(b) Write the rate equation for the reaction.

(c) Calculate a value for the rate constant, including appropriate units.