

**CORK INSTITUTE OF TECHNOLOGY  
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

**Autumn Examinations 2008/09**

**Module Title:     Physical and Organic Chemistry**

**Module Code:**        **CHEM 6003**

**School:**                Science

**Programme Title:**   Bachelor of Science in Applied Biosciences – Stage 1  
                              Bachelor of Science (Honours) in Herbal Science – Stage 1  
                              Bachelor of Science in Biomedical Science – Stage 1

**Programme Code:**   **SBIOS\_7\_Y1**  
                              **SHERB\_8\_Y1**  
                              **SBMSC\_7\_Y1**

**External Examiner(s):**     Dr. G. Keaveney

**Internal Examiner(s):**     Dr. R. Hourihane, Mr. D. Spicer

**Instructions:**                Attempt FOUR questions. Question 1 Section A is COMPULSARY.  
                                      Attempt at least ONE question from each Sections B and C and a fourth  
                                      question from either Sections B or C.

**Duration:**                2 Hours

**Sitting:**                    Autumn 2009

**Requirements for this examination:**

**Note to Candidates:** Please check the Programme Title and the Module Title to ensure that you have received the correct examination paper.  
If in doubt please contact an Invigilator.

## Section A

Attempt 8 of the following 10 parts. All carry equal marks

Q1. Attempt 8 of the following 10 parts. All carry equal marks

- (i) Write a first order rate law.
- (ii) Write an equilibrium expression for the following reactions
  - (a)  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$   $K = 1.2 \times 10^9$
  - (b)  $\text{WO}_3(\text{s}) + 3\text{H}_2(\text{g}) \rightleftharpoons \text{W}(\text{s}) + 3\text{H}_2\text{O}(\text{g})$
- (iii) In the case of reaction (a) in (ii) above does the equilibrium mixture contain mostly reactants or mostly products
- (iv) Identify the acid, base, conjugate acid, and conjugate base in the following acid base reactions
  - (a)  $\text{HBrO}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{BrO}^-$
  - (b)  $\text{HSO}_4^-(\text{aq}) + \text{HCO}_3^-(\text{aq}) \rightleftharpoons \text{SO}_4^{2-}(\text{aq}) + \text{H}_2\text{CO}_3(\text{aq})$
- (v) Define enthalpy of neutralisation. Identify an experimental procedure where this quantity could be determined.
- (vi) Write the structures of two constitutional **and** two configurational isomers of  $\text{C}_4\text{H}_8$ , butene.
- (vii) Why is methylamine a stronger base than ammonia?.
- (viii) Why do alcohols show a **decreasing** solubility in water as their molecular weights **increase**?
- (ix) Explain why pent-4-ene would be an incorrect name for an isomer of pentene.
- (x) Define what is meant by a functional group in an organic molecule.

(25 Marks)

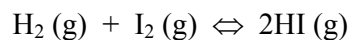
## Section B

- Q2. (a) Using the data in the following table, prove, ( graphically) that the decomposition of  $\text{N}_2\text{O}_5$  (g) at  $55^\circ\text{C}$ , obeys first order kinetics. Hence or otherwise determine a value for the specific rate constant.

Time /s	$[\text{N}_2\text{O}_5] / \text{mol/dm}^3$
0	0.0200
100	0.0169
200	0.0142
300	0.0120
400	0.0101
500	0.0086
600	0.0072
700	0.0061

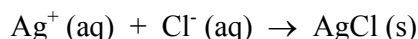
(15 Marks)

- (b) Calculate the equilibrium concentrations of  $\text{H}_2$ ,  $\text{I}_2$ , and  $\text{HI}$  gases at 700 K if the initial concentrations are  $[\text{H}_2] = 0.100 \text{ mol/dm}^3$  and  $[\text{I}_2] = 0.200 \text{ mol/dm}^3$ . The equilibrium constant,  $K$ , for the reaction as written below is 57.0 at this temperature.



(10 Marks)

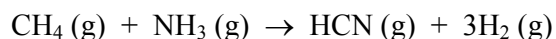
- Q3. (a) Aqueous silver ion reacts with aqueous chloride ion to yield a white precipitate of silver chloride according to the reaction below



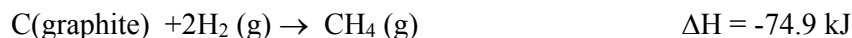
When 10 cm<sup>3</sup> of 1.00 mol/dm<sup>3</sup> AgNO<sub>3</sub> solution was added to 10 cm<sup>3</sup> of 1.00 mol/dm<sup>3</sup> NaCl solution at 25.0 °C in a calorimeter, a white precipitate of AgCl formed. The temperature of the aqueous mixture increased to 32.6 °C. Calculate the ΔH (in kilojoules) for the reaction assuming that the specific heat capacity of the aqueous mixture is 4.18 J/(g °C), that the density of the mixture is 1.00 g/dm<sup>3</sup> and that the calorimeter itself absorbs a negligible amount of heat.

OR

Hydrogen cyanide is a highly poisonous, volatile liquid. It can be prepared by the reaction



Use the following thermochemical equations to calculate the enthalpy of reaction at constant pressure?



- (b) Calculate the pH or [H<sup>+</sup>] where appropriate, of each of the following solutions

(i) 0.2 mol/dm<sup>3</sup> HNO<sub>3</sub>

(ii) 0.5 mol/dm<sup>3</sup> H<sub>2</sub>SO<sub>4</sub>

(iii) 0.4 mol/dm<sup>3</sup> H<sub>2</sub>C<sub>2</sub>O<sub>4</sub> (oxalic acid) K = 6.4 × 10<sup>-5</sup>

(iv) 5.5g Ca(OH)<sub>2</sub> in exactly 500 cm<sup>3</sup> of water

(v) a solution of pH 2.5

(12 Marks)

## Section C

- Q4. (a) Write a reaction sequence which explains how a polymer of an alkene is synthesised. (10 Marks)
- (b) What is the major product formed when butan-2-ol is dehydrated? Briefly explain your answer and quote the appropriate rule. (5 Marks)
- (c) Write the balanced chemical equation for the combustion of butane in oxygen. (5 Marks)
- (d) Using the equation in (c) above, calculate the weight of water formed when 1 mole of butane is combusted in oxygen. (5 Marks)
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- Q5. (a) Write the mechanism for the hydration of but-2-ene in the presence of a strong acid. Account for the formation of butan-2-ol as the only product. (10 Marks)
- (b) Why are alkenes said to be unsaturated compounds? Explain your answer. (5 Marks)
- (c) (i) How can ethanol be chemically converted into ethanoic acid (acetic acid)? (5 Marks)
- (ii) Write the chemical equation of the reaction which occurs when ethanol reacts with ethanoic acid to form an ester. (5 Marks)