

**CORK INSTITUTE OF TECHNOLOGY  
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

**Semester 2 Examinations 2010/11**

<b>Module Title:      Physical and Organic Chemistry</b>
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**Module Code:**          **CHEM 6003**

**School:**                  Science

**Programme Title:**    Bachelor of Science in Applied Biosciences & Biotechnology – Year 1  
Bachelor of Science (Honours) in Herbal Science – Year 1  
Bachelor of Science (Honours) in Nutritional Health Science – Year 1  
Bachelor of Science (Honours) in Pharmaceutical Biotechnology – Year 1  
Bachelor of Science in Applied Physics and Instrumentation – Year 1  
Bachelor of Science (Honours) in Biomedical Science – Year 1  
Bachelor of Science (Honours) in Environmental Science and Sustainable  
Technology – Year 1

**Programme Code:**    **SBIOS\_7\_Y1**  
**SHERB\_8\_Y1**  
**SNHSC\_8\_Y1**  
**SPHBI\_8\_Y1**  
**SPHYS\_7\_Y1**  
**SBISC\_8\_Y1**  
**SESST\_8\_Y1**

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

**Internal Examiner(s):**      **Dr. R. Hourihane, Dr. M. Lehane, Ms. C. Griffin**

**Instructions:**              **Attempt four Questions. Question ONE, SECTION A is compulsory.**  
**Attempt ONE question each from SECTIONS B and C, and ONE**  
**other question.**  
**Show all calculations on the examination script.**

**Duration:**          2 Hours

**Sitting:**                  Summer 2011

**Requirements for this examination:**          Maths Tables

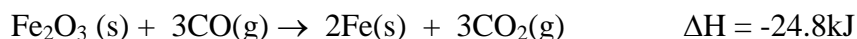
<p><b>Note to Candidates:</b> Please check the Programme Title and the Module Title to ensure that you have received the correct examination paper. If in doubt please contact an Invigilator</p>
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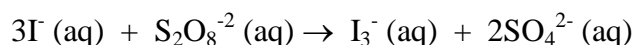
## Section A

**Q1.** Attempt 8 of the following. All carry equal marks.

- (i) How much heat (in kJ) , is evolved or absorbed in the reaction of 2.50g of  $\text{Fe}_2\text{O}_3(\text{s})$  with enough carbon monoxide to produce iron metal?

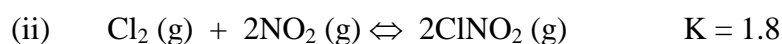
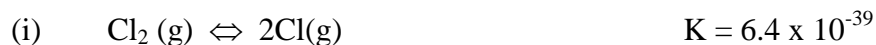


- (ii) The oxidation of iodide ion by per-oxydisulfate ion is described by the following reaction



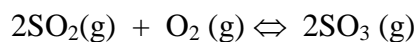
If the rate of consumption of  $\text{S}_2\text{O}_8^{2-}$  is  $1.5 \times 10^{-3} \text{ Ms}^{-1}$ , what is the rate of consumption of  $\text{I}^-$ , and the rate of formation of  $\text{SO}_4^{2-}$ ?

- (iii) For which of the following reactions will the equilibrium mixture contain an appreciable concentration of both reactants and products

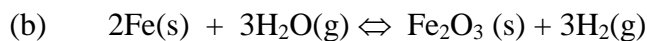
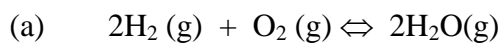


- (iv) An equilibrium mixture of  $\text{O}_2$ ,  $\text{SO}_2$ , and  $\text{SO}_3$  contains equal concentration of  $\text{SO}_2$  and  $\text{SO}_3$ . Calculate the concentration of  $\text{O}_2$  if

$K = 2.7 \times 10^2$  for the following reaction



- (v) For each of the following equilibria, use Le Chatelier's principle to predict the direction of the reaction, when the volume of the reaction vessel is increased, explaining briefly your predictions. What will be the concentrations of each species when the equilibrium is re-established?



- (vi) Give the formula of the conjugate base of each of the following Bronsted-Lowry acids

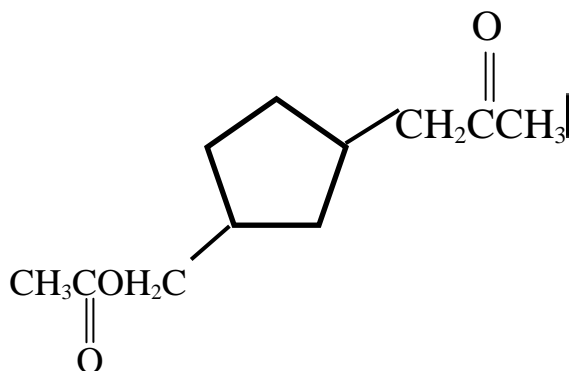


- (vii) Calculate the pH of each of the following solutions

- 4.8g of lithium hydroxide,  $(\text{LiOH})$  in water to give 250mL of solution.
- 50.0mL of  $0.10 \text{ mol dm}^{-3}$   $\text{HCl}$  diluted to 1.00L.



- (viii) Calculate the percentage composition by weight of ether  $(C_2H_5)_2O$
- (ix) Ethanol and dimethyl ether are isomers, both having the molecular formula  $C_2H_6O$  draw the structure for each and predict (providing an explanation) which has the highest boiling point.
- (x) Circle and name the substituent types in the following molecule:

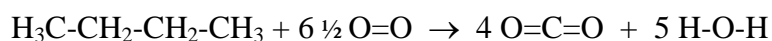


- (xi) Describe the uses and applications of the lower molecular weight ( $C = 1-10$ ) alkanes.
- (xii) Cyclohexane is often represented in the literature as being a hexagonal shaped molecule; however it exists in 2 spatial conformations. Sketch these and comment on their relative stability.

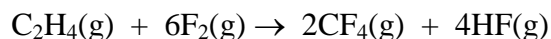


## Section B

- Q2.** (i) Identify two extensive state functions by name and symbol. Explain what is meant by the underlined term. (5 marks)
- (ii) Using the table of Average Bond Enthalpies attached and the equation below, calculate the approximate heat of combustion for butane, (C<sub>4</sub>H<sub>10</sub>). Explain why the value is approximate? (7 marks)



- (iii) From the thermo-chemical data listed below, calculate the  $\Delta H$  for the reaction of ethylene with fluorine. (8 marks)



- (a)  $\text{H}_2(\text{g}) + \text{F}_2(\text{g}) \rightarrow 2\text{HF}(\text{g})$   $\Delta H = -537 \text{ kJ}$
- (b)  $\text{C}(\text{s}) + 2\text{F}_2(\text{g}) \rightarrow \text{CF}_4(\text{g})$   $\Delta H = -680 \text{ kJ}$
- (c)  $2\text{C}(\text{s}) + 2\text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_4(\text{g})$   $\Delta H = +52.3 \text{ kJ}$

- (iv) When a 9.55g sample of solid sodium hydroxide is dissolved in 100g of water in a coffee cup calorimeter, the temperature rises from 23°.6 to 47°.4 C. Calculate  $\Delta H$ , (in  $\text{kJ mol}^{-1} \text{NaOH}$ ), for the solution process.

$$\text{s.h.c of H}_2\text{O} = 4.18 \text{ J g}^{-1} \text{ } ^\circ\text{C}^{-1}$$





- Q3.** (i) The initial rates listed in the following table were determined for the reaction
- $$2\text{NO(g)} + \text{Cl}_2\text{(g)} \rightarrow 2\text{NOCl(g)}$$

Experiment	Initial [NO]/M	Initial [Cl <sub>2</sub> ]/M	Initial Rate Ms <sup>-1</sup>
1	0.13	0.20	1.0x10 <sup>-2</sup>
2	0.26	0.20	4.0x10 <sup>-2</sup>
3	0.13	0.10	5.0x10 <sup>-3</sup>

- (a) Write the rate law. Determine the order of the reaction.  
 (b) Calculate the value for the specific rate constant  
 (c) What is the reaction rate when both reactant concentrations are 0.12M?

(10marks)

- (ii) The reaction described by the following reaction is first order in SO<sub>2</sub>Cl<sub>2</sub>.



Using the following kinetic data determine the magnitude of the first order rate constant. Hence or otherwise determine the half life for the process.

Time /s	Pressure SO <sub>2</sub> Cl <sub>2</sub> /atm
0	1.000
2,500	0.947
5,000	0.895
7,500	0.848
10,000	0.803

(8 marks)

- (iii) List three properties a catalyst ideally possesses.

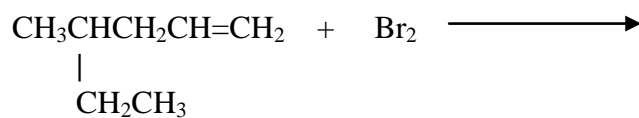
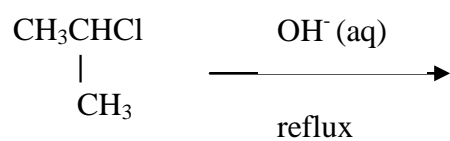
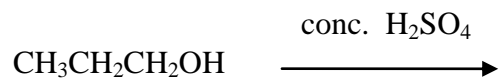
Describe surface adsorption theory for heterogeneous catalysis. A well labelled simple diagram is required.

(7 marks)



## Section C

Q4. (a) Predict the products of the following reactions:



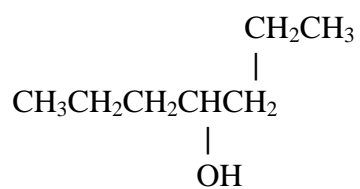
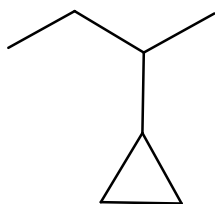
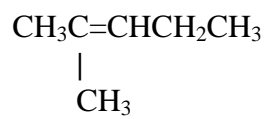
(7 marks)

(b) Indicate how you would prepare (1) an alkane from an alkene (2) acetic acid from ethyl alcohol.

(7 marks)



(c) Name the following 3 compounds using the IUPAC rules



(7 marks)

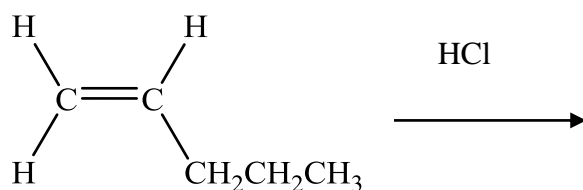
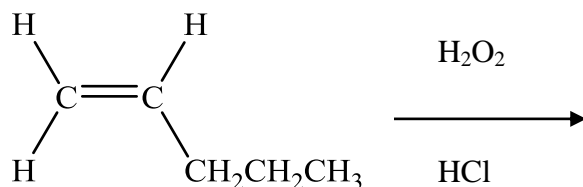
(d) Draw the structure of 4-ethyl-3,4-dimethyl-2-hexene

(4 marks)



Q5. (a) Describe  $sp^3$  and  $sp^2$  hybridisation as observed in the alkanes and alkenes respectively (support your answer with diagrams). (6 marks)

(b) Predict the product(s) formed from the following reactions and give reasons for your predictions



(7 marks)

c) Explain the follow terms and support your answer with examples and diagrams:

- Primary ( $1^0$ ), Secondary ( $2^0$ ) and Tertiary ( $3^0$ ) alcohols
- Electrophile and nucleophile
- Structural and Geometric Isomers
- Saturation and Unsaturation in Hydrocarbons
- Hydrocarbon Cracking

(12 Marks)