NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
SUPPLEMENTARY EXAMINATIONS – AUGUST 2014
PHYSICAL CHEMISTRY I – SCH 2104
TIME: 3 HOURS

INSTRUCTIONS TO CANDIDATES

Answer ALL questions.
Answer each question on a FRESH page.
$R = 8.314 JK^{-1} mol^{-1} = 0.08206 dm^3 atm\ K^{-1} mol^{-1}$
1 atm = 760 torr = 760mmHg = 101 325 Pa
$\ln x = 2.3026 \log_{10} x$

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1. a) Discuss how the Second Law of Thermodynamics was derived. [7 marks]

   b) One mole of a monatomic ideal gas is initially at 273 K and 1atm.
      i) What is the initial internal energy?
      ii) Find its final internal energy and the work done by the gas when 500 J of heat are added at constant pressure.
      iii) Find the same quantities when 500 J of heat are added at constant volume. [10 marks]

   c) Explain the concept "the higher you go the cooler it becomes". [8 marks]

2. a) With the aid of appropriate diagrams, discuss a heat pump. [12 marks]

   b) Discuss why the Carnot engine is the most efficient engine. [13 marks]

3. a) Calculate, q, w and ΔH for the vaporization of 2.5g of liquid water at 2.1 atm and 100°C. Make the following assumptioms:
      (i) density of liquid water at 100°C is 1g/mL.
      (ii) Water vapour is described by the ideal gas equation.
      (iii) External pressure is constant at 2.1 atm [12 marks]

   b) Given that two phases (α and β) are at equilibrium and

$d\mu_\alpha = -S_{m,\alpha}dT + V_{m,\alpha}dP$; derive the Clapeyron equation shown below

$$\frac{dP}{dT} = \frac{\Delta S_m}{\Delta V_m}$$

Hence use it to explain why for some compounds the solid-liquid phase boundary curve has a negative slope while for others the slope is positive. [13 marks]

4. a) A mixture of CO(g), H_2 (g), and CH_3OH(g) at 500K with P_{CO} = 10 bar, P_{H_2} = 1 bar and $P_{CH_3OH} = 0.1\ bar$ is passed over a catalyst.

For the reaction, $CO(g) + 2H_2(g) \rightleftarrows CH_3OH(g)$; Confirm that the reaction is not spontaneous in the forward direction. What is the minimum temperature required for the reaction to be spontaneous in the forward direction?

Given that $\Delta rG^0 = 21.21 kJ\ mol^{-1}$. [13 marks]

b) Considering the Kw data for different temperatures given in the table below:

◦C	K_w
10	0.29×10^{-14}
25	1.00×10^{-14}
50	5.48×10^{-14}

Using the following equations discuss whether the autoionization reaction is exothermic or endothermic?

$\ln K = \frac{-\Delta_R G^0}{RT}$, and $G = H - TS$. [12 marks]

End of question Paper!!!