University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER II EXAMINATION - 2009

CHEM 10030

Chemistry For Engineers

Professor Cole-Hamilton

Professor Graetzel

Professor Waghorne

Dr. Sullivan *

Professor Sidebottom *

Time Allowed: 2 hours

Instructions for Candidates

All questions carry equal marks; the approximate assignment of marks to parts of a question is indicated (as a percentage) in parentheses.

Use a separate answer book provided for each question.

No rough work sheets are to be used. The rough work for each question should be included in the answer book for that question.

Instructions for Invigilators

The use of electronic calculators is permitted
A Periodic Table of the Elements is attached to these sheets
Graph paper should be provided

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Answer ***both*** question 1 ***and*** question 2.

ONLY ANSWER QUESTION 3 IF YOU ARE SEEKING TO IMPROVE YOUR PRACTICAL MARK!

1. Answer ***either*** part (a) ***or*** part (b) and ***any four*** parts (c) – (h).

(a) Draw a diagram showing the experiment that Curie performed using radioactive Radium and explain how her conclusions following this experiment furthered the development of modern atomic theory. (40)

(b) Discuss the experiment Rutherford performed using α particles and gold foil. Explain how his results disproved the atomic theory previously proposed by Thompson. (40)

Answer ***any four*** parts (c) – (h).

(c) Chlorine has two stable isotopes, ^{35}Cl with a mass of 34.97 (and abundance of 75.77%) and ^{37}Cl with a mass of 36.95. What is the relative atomic mass of chlorine? (15)

(d) For a hydrogen atom, calculate the wavelength of a photon that results from the transition of an electron from $n = 4$ to $n = 2$. The Rydberg constant is $-2.18 * 10^{-18}$ J, the speed of light is $3*10^{8}$ ms^{-1} and Planck's constant is $6.626*10^{-34}$Js. (15)

(e) Write the electronic configurations of the following atoms and ions, He, Na, Na^{+}, O, O^{2-}, Mg^{2+}. (15)

(f) Draw an approximate potential energy diagram (Energy V Inter nuclear distance) for the formation of a molecule of Br_2 from two Br atoms, given that the Bond Length of a Br_2 molecule is 229 pm and the bond energy is 224 kJ mol^{-1}. (15)

(g) Draw Lewis structures of the following molecules, H_2S, PH_3 and CBr_4. Use VSEPR theory to determine their shapes. (15)

(h) Determine the % C in C_6H_6. What mass of CO_2 and what number of moles of H_2O are produced from the combustion of 1 mole of C_6H_6? (15)

2. Answer ***all*** parts (a) – (d).

(a) Answer ***both*** parts (i) ***and*** (ii). (25)

(i) Use the data given below to calculate the enthalpy change at 298 K for the reaction:

$$N_2O_{4\,(g)} + 3CO_{(g)} \rightarrow N_2O_{(g)} + 3CO_{2\,(g)}$$

$\Delta H_f^0\,(N_2O_{(g)}) = 81\ kJ\ mol^{-1}$

$\Delta H_f^0\,(CO_{2\,(g)}) = -393\ kJ\ mol^{-1}$

$\Delta H_f^0\,(N_2O_{4(g)}) = 10\ kJ\ mol^{-1}$

$\Delta H_f^0\,(CO_{(g)}) = -110\ kJ\ mol^{-1}$

(ii) Draw the enthalpy diagram for the reaction including the elements in their standard states

(b) Answer ***both*** parts (i) ***and*** (ii). (25)

(i) Write an expression for the equilibrium constant for the reaction:

$$2NO_{2(g)} \leftrightarrow N_2O_{4(g)}$$

Initially, 1.0 mol of NO_2 and 1.0 mol of N_2O_4 were present in a 1L flask. When equilibrium was reached the concentration of N_2O_4 was 0.75 mol L^{-1}

(ii) Calculate the concentration of NO_2 at equilibrium and hence the equilibrium constant for the reaction.

(c) The decomposition of a compound A to give products gave the following kinetic data: (25)

[A], mol L^{-1}	Time, s
0.583	0.0
0.303	9.0
0.123	17.0
0.063	25.0
0.029	35.0

Determine the order of the reaction and calculate the rate constant.

(d) Calculate the activation energy for a reaction which doubles in rate when the temperature is increased from 298 K to 398 K. (25)

(Gas constant, $R = 8.314$ J mol^{-1} K^{-1})

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3. Answer ***any*** part (a) – (c).

(a) Describe an experiment used to measure the strength of a hydrogen bond using infra red spectroscopy. (40)

(b) Describe an experiment which separates, identifies and quantifies the chemical components of a mixture. (40)

(c) Describe an experiment that measures the rate of the chemical reaction between I_2 and $(CH_3)_2CO$. (40)

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Periodic Table of the Elements

1 I	2 II					Group (new notation) Group (old notation)						13 III	14 IV	15 V	16 VI	17 VII	18 VIII
1 Hydrogen H 1.0079						N Name E. Mass	Atomic number Name Symbol Atomic mass										2 Helium He 4.0026
3 Lithium Li 6.941	4 Beryllium Be 9.0122											5 Boron B 10.811	6 Carbon C 12.0112	7 Nitrogen N 14.0067	8 Oxygen O 15.9994	9 Fluorine F 18.9984	10 Neon Ne 20.18
11 Sodium Na 22.989	12 Magnesium Mg 24.305	3	4	5	6	7	8	9	10	11	12	13 Aluminium Al 26.9815	14 Silicon Si 28.086	15 Phosphorus P 30.9738	16 Sulfur S 32.066	17 Chlorine Cl .	18 Argon Ar 39.948
19 Potassium K 39.0983	20 Calcium Ca 40.08	21 Scandium Sc 44.956	22 Titanium Ti 47.87	23 Vanadium V 50.942	24 Chromium Cr 51.996	25 Manganese Mn 54.938	26 Iron Fe 55.847	27 Cobalt Co 58.933	28 Nickel Ni 58.69	29 Copper Cu 63.546	30 Zinc Zn 65.39	31 Gallium Ga 69.723	32 Germanium Ge 72.61	33 Arsenic As 74.922	34 Selenium Se 78.96	35 Bromine Br 79.904	36 Krypton Kr 83.80
37 Rubidium Rb 85.468	38 Strontium Sr 87.62	39 Yttrium Y 88.905	40 Zirconium Zr 91.224	41 Niobium Nb 92.906	42 Molybdenum Mo 95.94	43 Technetium Tc 98	44 Ruthenium Ru 101.07	45 Rhodium Rh 102.905	46 Palladium Pd 106.42	47 Silver Ag 107.868	48 Cadmium Cd 112.411	49 Indium In 114.82	50 Tin Sn 118.71	51 Antimony Sb 121.75	52 Tellurium Te 127.60	53 Iodine I 126.904	54 Xenon Xe 131.29
55 Cesium Cs 132.905	56 Barium Ba 137.34	57 Lanthanum La 138.91	72 Hafnium Hf 178.49	73 Tantalum Ta 180.948	74 Tungsten W 183.85	75 Rhenium Re 186.207	76 Osmium Os 190.2	77 Iridium Ir 192.22	78 Platinum Pt 195.09	79 Gold Au 196.967	80 Mercury Hg 200.59	81 Thallium Tl 204.38	82 Lead Pb 207.19	83 Bismuth Bi 208.98	84 Polonium Po 209	85 Astatine At 210	86 Radon Rn 222
87 Francium Fr 223	88 Radium Ra 226	89 Actinium Ac 227	104 Rutherfordium Rf 261	105 Dubnium Db 262	106 Seaborgium Sg 266	107 Bohrium Bh 264	108 Hassium Hs 269	109 Meitnerium Mt 268									

Lanthanides	58 Cerium Ce 140.12	59 Praesodymium Pr 140.907	60 Neodymium Nd 144.24	61 Promethium Pm 144.913	62 Samarium Sm 150.35	63 Europium Eu 151.96	64 Gadolinium Gd 157.25	65 Terbium Tb 158.925	66 Dysprosium Dy 162.50	67 Holmium Ho 164.93	68 Erbium Er 167.26	69 Thulium Tm 168.934	70 Ytterbium Yb 173.04	71 Lutetium Lu 174.97
Actinides	90 Thorium Th 232.038	91 Protactinium Pa 231.036	92 Uranium U 238.03	93 Neptunium Np 237.048	94 Plutonium Pu 244.064	95 Americium Am 243	96 Curium Cm 247	97 Berkelium Bk 247	98 Californium Cf 242.058	99 Einsteinium Es 254	100 Fermium Fm 257.095	101 Mendelevium Md 258.10	102 Nobelium No 259.101	103 Lawrencium Lr 260.105