University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER I EXAMINATION - 2008

CHEM 10030

Chemistry For Engineers

Professor Cole-Hamilton

Professor Wayne

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 loose 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

S1005 (S)

Answer ***both questions 1 and 2***

Question 1

Answer any *three* of the following (a) – (e)

(a) Answer *all* sections (i) – (iii)

(i) Explain what happens when an electric discharge is passed through hydrogen contained at low pressure in a transparent tube and discuss how the observations further developed atomic theory. (10)

(ii) Why does the Bohr model of the atom not apply to any other related discharge experiment using Hg or Ne, or any other neutral atom? (10)

(iii) Determine the wavelength of the light emitted when an electron makes a transition from the n=4 orbital to the n=2 orbital in a hydrogen atom. (13.3)

Planck's constant, $h = 6.626 \times 10^{-34}$ Js.
Rydberg constant, $R = 2.18 \times 10^{-18}$ J.
Speed of light, $c = 3 \times 10^{8}$ ms^{-1}.

(b) Answer *all* sections (i) – (iii)

(i) Briefly discuss how isotopes differ from one another and name three areas where the isotopes have given diagnostic or historical information. (10)

(ii) Charged particles are deflected as they move through a magnetic field. State the features that affect the extent of this deflection. (10)

(iii) An element consists of two isotopes. The abundance of one isotope is 95.72% and its atomic mass is 114.9041 u. The atomic mass of the second isotope is 112.9043 u. What is the average atomic mass of the element? (13.3)

(c) Answer *all* sections (i) – (ii)

(i) Why is the oxidation of hydrocarbon fuels always an exothermic process? (20)

(ii) Determine the number of moles of CO_2 and the mass of H_2O formed following the combustion of 500kg of C_3H_8. (13.3)

(d) Answer *all* sections

Draw Lewis structures and predict the shapes of the following molecules:

N_2	(5)
CO_2	(5)
CH_4	(5)
C_2H_6	(5)
C_2H_4	(7)
C_2H_2	(7.3)

(e) Answer *all* sections (i) – (iii)

(i) Explain, with examples, ionic bonding. (5)

(ii) Explain covalent bonding in terms of the attractions and repulsions that components of an atom experience as two atoms approach one another. (8.3)

(iii) Given the following data, roughly sketch (on one plot) the potential energy curves for the formation C–C , C=C and C≡C bonds (carbon-carbon single, double and triple bonds).

	Bond length / pm	Bond strength / kJ mol^{-1}
C–C	154	346
C=C	134	610
C≡C	120	835

Comment on the relative magnitudes of the bond lengths and energies as a function of bond order and explain each part of one of the energy profiles in terms of the changes in the extents of the attractive and repulsive forces experienced by the components of the atoms as a function of the inter-nuclear distance. (20)

Question 2 is on the next page.....

Question 2

Answer *all* sections (a)-(d)

(a) The molar enthalpy for the combustion of ethene, (25)

$$C_2H_{4\,(g)} + 3O_{2\,(g)} \rightarrow 2CO_{2\,(g)} + 2H_2O_{\,(l)}$$

is -1411 kJ mol^{-1} at 298 K. Calculate the standard enthalpy of formation of ethene from the following data:

$\Delta H_f^\circ\,(CO_{2\,(g)}) = -394$ kJ mol^{-1}

$\Delta H_f^\circ\,(H_2O_{\,(l)}) = -286$ kJ mol^{-1}

Sketch the enthalpy diagram for the combustion of ethene including the elements in their standard states.

(b) Write an expression for the equilibrium constant for the exothermic reaction : (25)

$$C_{(s)} + 2H_{2\,(g)} \rightleftharpoons CH_{4\,(g)}$$

Predict the effect on the amount of CH_4 in the system if:

(i) the reaction volume is decreased

(ii) the temperature is increased

(c) The reaction of hydrogen with nitric oxide in the gas phase, (25)

$$2H_2 + 2NO \rightarrow N_2 + 2H_2O$$

is complex and takes place by the three elementary reactions:

(1) $2NO \rightleftharpoons N_2O_2$ Rapidly established equilibrium, Equilibrium constant K_1

(2) $N_2O_2 + H_2 \rightarrow N_2O + H_2O$ Slow rate determining step, Rate constant k_2

(3) $N_2O + H_2 \rightarrow N_2 + H_2O$ Rapid reaction, Rate constant k_3

Show that the rate equation for the formation of N_2 is of the form:

$d[N_2]/dt = k[NO]^2[O_2]$

Section (d) is on the following page.....

(d) Explain in terms of chemical kinetics why each of the following increases the rate of a chemical reaction: (25)

(i) the presence of a catalyst
(ii) an increase in temperature
(iii) an increase in reactant concentrations.

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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 = Atomic number Name = Name **El** = Symbol Mass = 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** 35.453	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