University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER II RESIT EXAMINATIONS

2010/11

CHEM 10030

Chemistry for Engineers

Professor Wayne

Professor Waghorne

Dr Sullivan*

Dr Baldelli

Time Allowed: 2 Hours

Instructions for Candidates

The assignment of marks to parts of a question is indicated (as a percentage of the entire paper) 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.

ONLY STUDENTS SEEKING TO IMPROVE THEIR LABORATORY GRADE SHOULD ATTEMPT QUESTION 3

Instructions for Invigilators

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

1. Answer ***any three*** parts (a) – (e).

(a) 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) Draw Lewis structures of the following molecules: H_2S, PH_3, CBr_4. Use VSEPR theory to determine their shapes. **(13)**

(b) Answer ***all*** parts (i) – (iii).

(i) Explain why the combustion of CH_4 releases heat. **(10)**

(ii) 0.230 g of a hydrocarbon is burned in excess O_2 and produces 0.758 g of CO_2 and 0.207 g of H_2O. Determine the empirical formula. **(10)**

(iii) Determine the percentage of 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? **(13)**

(c) Answer ***both*** sections (i) and (ii).

(i) 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. **(20)**

(ii) Chlorine has two stable isotopes, ^{35}Cl with a mass of 34.97 and ^{37}Cl with a mass of 36.95. Given the atomic mass of chlorine is 35.45 determine the ratio of ^{35}Cl to ^{37}Cl. **(13)**

(d) Answer ***all*** sections (i) – (iii).

(i) Explain, with examples, ionic bonding. **(10)**

(ii) Explain covalent bonding in terms of the attractions and repulsions that components of an atom experience as two atoms approach one another. **(10)**

Question continues on the next page…

(iii) Given the following data, roughly sketch (on one plot) the potential energy curves for the formation of C – C, C=C and C≡C bonds (carbon – carbon single, double and triple bonds). **(13)**

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

(e) Answer ***both*** sections (i) – (ii).

(i) Discuss the hydrogen emission spectrum in terms of the Bohr model of the atom. **(20)**

(ii) For a hydrogen atom, calculate the wavelength of a photon that results from the transition $n = 4$ to $n = 2$. The Rydberg constant is 2.180×10^{-18} J, the speed of light is 2.998×10^{8} m s^{-1} and Planck's constant is 6.626×10^{-34} J s. **(13)**

2. Answer ***any two*** parts (a) – (c).

(a) The reaction between chlorine and methane

$$Cl_2 + CH_4 \rightleftharpoons HCl + CH_3Cl$$

is endothermic. Write an expression for the equilibrium constant for the reaction.

Describe and explain the effects of the following changes on the position of equilibrium:

(i) Addition of HCl;
(ii) Addition of the inert gas helium;
(iii) An increase in the temperature. **(50)**

Question continues on the next page…

(b) Methanol is produced commercially from the reaction between carbon monoxide and hydrogen

$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$

Using the data given below, calculate the enthalpy, $\Delta H^{\ominus}$, entropy, $\Delta S^{\ominus}$, and free energy, $\Delta G^{\ominus}$, changes and the equilibrium constant, K, at 298K for the reaction.

	$\Delta H_f^{\ominus}$/ kJ mol^{-1}	$S^{\ominus}$/ J K mol^{-1}	
CO(g)	-110	198	
$H_2(g)$	0	131	
$CH_3OH(g)$	-201	240	**(50)**

(c) Answer ***both*** sections (i) ***and*** (ii).

(i) Explain the effect of a catalyst on the rate and position of equilibrium of a chemical reaction;

(ii) Determine the activation energy of an elementary reaction in which the rate constant doubles when the temperature increases from 300 K to 1000 K.

(Gas constant, R, = 8.314 J mol^{-1} K^{-1}) **(50)**

3. STUDENTS SHOULD ONLY ANSWER THIS QUESTION IF THEY SEEK TO IMPROVE THEIR PRACTICAL MARK.

Answer ***one*** part (a) ***or*** (b).

(a) Describe an experiment used to measure the strength of a hydrogen bond using infrared spectroscopy; **(40)**

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

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Periodic Table of the Elements

1	2											13	14	15	16	17	18
I	II					Group (new notation)						III	IV	V	VI	VII	VIII
						Group (old notation)											

1 Hydrogen **H** 1.0079						N Name **El** 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** 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 Gadoloinium **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 Proactinium **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