



University College Dublin  
An Coláiste Ollscoile, Baile Átha Cliath

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**SEMESTER II RESIT EXAMINATIONS**

**2010/11**

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**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:  $\text{H}_2\text{S}$ ,  $\text{PH}_3$ ,  $\text{CBr}_4$ . Use VSEPR theory to determine their shapes. **(13)**

(b) Answer **all** parts (i) – (iii).

- (i) Explain why the combustion of  $\text{CH}_4$  releases heat. **(10)**
- (ii) 0.230 g of a hydrocarbon is burned in excess  $\text{O}_2$  and produces 0.758 g of  $\text{CO}_2$  and 0.207 g of  $\text{H}_2\text{O}$ . Determine the empirical formula. **(10)**
- (iii) Determine the percentage of C in  $\text{C}_6\text{H}_6$ . What mass of  $\text{CO}_2$  and what number of moles of  $\text{H}_2\text{O}$  are produced from the combustion of 1 mole of  $\text{C}_6\text{H}_6$ ? **(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,  $^{35}\text{Cl}$  with a mass of 34.97 and  $^{37}\text{Cl}$  with a mass of 36.95. Given the atomic mass of chlorine is 35.45 determine the ratio of  $^{35}\text{Cl}$  to  $^{37}\text{Cl}$ . **(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 <sup>-1</sup>
C – C	154	346
C=C	134	610
C≡C	120	835

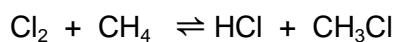
- (e) Answer **both** sections (i) – (ii).

- (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  $2.180 \times 10^{-18}$  J, the speed of light is  $2.998 \times 10^8$  m s<sup>-1</sup> and Planck's constant is  $6.626 \times 10^{-34}$  J s. **(13)**

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

- (a) The reaction between chlorine and methane



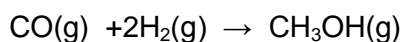
is endothermic. Write an expression for the equilibrium constant for the reaction.

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



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.

	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K mol}^{-1}$	
CO(g)	-110	198	
H <sub>2</sub> (g)	0	131	
CH <sub>3</sub> OH(g)	-201	240	<b>(50)</b>

- (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,  $R$ , =  $8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ ) **(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 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		<div><div>N Name El Mass</div><div>Atomic number Name Symbol Atomic mass</div></div>																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 Praseodymium 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		
				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		
Actinides																			