



University College Dublin  
An Coláiste Ollscoile, Baile Átha Cliath

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**SEMESTER I EXAMINATION - 2009**

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**CHEM 10030**  
**Chemistry For Engineers**

Professor Powell

Professor Wayne

Professor Waghorne

Dr. Sullivan \*

Dr. Quinn

**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

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

**Question 1**

Answer any **four** of the following (a) – (f)

(a) Answer **both** sections (i) and (ii)

- (i) Draw a schematic diagram of the cathode-ray tube apparatus used by Thompson and explain how his experiments furthered the development of atomic theory; (15)
- (ii) Draw a schematic diagram of the experiment that confirmed the existence of the nucleus and label the individual components. (10)

(b) Answer **both** sections (i) and (ii)

- (i) Explain the principle of operation of a mass spectrometer;
  - (ii) An element exists as one of four possible isotopes. 83.7% of all atoms of the element have a relative atomic mass of 51.94, 4.3% have a mass of 49.95, 9.5% have a mass of 52.94 and the remainder has a relative atomic mass of 53.94. Identify the element and determine its average relative atomic mass. (15)
- (10)

Continued.....

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

(i) Draw and label (using the graph paper provided) a potential energy diagram showing PE as a function of inter atomic distance for two Br atoms given that the bond strength of a Br–Br bond is  $193 \text{ kJ mol}^{-1}$  and the inter nuclear distance is 229 pm. (15)

(ii) Explain the magnitude of the PE when the two Br nuclei are (a) 1 m, (b) 229 pm and (c) 25 pm apart. (10)

(d) Answer **all** sections

Draw Lewis structures and VSEPR models of the following molecules. Ensure that you show electron counts, discriminate between lone pairs and bonding pairs of electrons, and state the final shapes of the molecules.

$\text{BF}_3$  (5)

$\text{SF}_6$  (5)

$\text{C}_2\text{H}_4$  (5)

$\text{H}_2\text{O}$  (5)

$\text{PCl}_5$  (5)

(e) Answer **both** sections (i) and (ii)

(i) Explain why heat is given out when a hydrocarbon reacts with  $\text{O}_2$  to form  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . (15)

(ii) Determine the mass of  $\text{CO}_2$  and the number of moles of  $\text{H}_2\text{O}$  formed when 20kg of octane ( $\text{C}_8\text{H}_{18}$ ) is fully burned. (10)

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

Continued.....

- (f) Answer **both** sections (i) and (ii)
- (i) Explain the appearance of the hydrogen emission spectrum using the Bohr model of the atom. (15)
- (ii) Determine the wavelength of the photon emitted when an electron in a H atom falls from the  $n=5$  to the  $n=2$  level. In what region of the electromagnetic spectrum would light of this wavelength be found?
- Planck's constant,  $h = 6.626 \times 10^{-34}$  J s.  
Rydberg constant,  $R = 2.18 \times 10^{-18}$  J.  
Speed of light,  $c = 3 \times 10^8$  m s<sup>-1</sup>. (10)

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

## Question 2

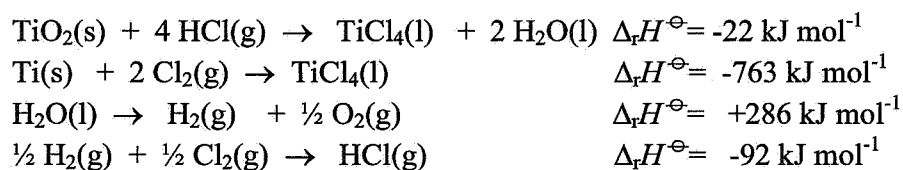
Answer all parts (a)-(c)

(a) Answer **all** parts (i), (ii) **and** (iii)

(i) State Hess's Law;

(ii) Define the standard state of an element;

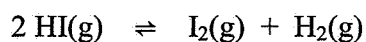
(iii) Given the following information:



(33.3)

Calculate the standard enthalpy of formation of  $\text{TiO}_2$ ;

(b) For the exothermic reaction:



Write an expression for the equilibrium constant in terms of concentrations.

When 0.2 moles of pure HI is added to a 2 L flask at 726 K it was found that 0.156 moles of HI remained when equilibrium was reached.

What are the equilibrium concentrations of  $\text{I}_2$  and  $\text{H}_2$ ?

Calculate the equilibrium constant.

What effect would increasing the reaction temperature have on the amount of  $\text{I}_2$  at equilibrium? Explain your reasoning.

(33.3)

Continued.....

(c) Answer **all** parts (i), (ii) **and** (iii).

(i) Explain briefly the meaning of the following terms in chemical kinetics:

*Rate equation*

*Activation energy*

*Reaction half-life*

(ii) The radioactive isotope  $^{123}\text{I}$  breaks down in a first-order process with a half-life of  $4.7 \times 10^4$  s at 25 °C. Calculate the rate constant for the decay.

(iii) Using a reaction-energy diagram briefly explain how a catalyst increases the rate of reaction.

(33.3)

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# Periodic Table of the Elements

1		2		Group (new notation)												Group (old notation)																			
I		II																																	
1		2		N												Atomic number																			
Hydrogen		Helium		Name												Name																			
H		He		El												Symbol																			
Mass		Mass		Atomic mass												Atomic mass																			
3	Lithium	4	Beryllium																																
6.941	Li	9.0122	Be																																
11	Sodium	12	Magnesium																																
22.989	Na	24.305	Mg																																
19	Potassium	20	Calcium	21	Scandium	22	Titanium	23	Vanadium	24	Chromium	25	Manganese	26	Iron	27	Cobalt	28	Nickel	29	Copper	30	Zinc	31	Gallium	32	Germanium	33	Arsenic	34	Selenium	35	Bromine	36	Krypton
39.0983	K	40.08	Ca	44.956	Sc	47.87	Ti	50.942	V	51.996	Cr	54.938	Mn	55.847	Fe	58.933	Co	58.69	Ni	63.546	Cu	65.39	Zn	69.723	Ga	72.61	Ge	74.922	As	78.96	Se	79.904	Br	83.80	
87.62	Rb	87.62	Sr	88.905	Y	91.224	Zr	92.906	Nb	95.94	Mo	98	Tc	101.07	Ru	102.905	Rh	106.42	Pd	107.868	Ag	112.411	Cd	114.82	In	118.71	Sn	121.75	Sb	127.60	Te	126.904	I	131.29	
137.34	Cs	137.34	Ba	138.91	La	178.49	Hf	180.948	Ta	183.85	W	186.207	Re	190.2	Os	192.22	Ir	195.09	Pt	196.967	Au	200.59	Hg	204.38	Tl	207.19	Pb	208.98	Bi	209	Po	210	At	222	
223	Fr	226	Ra	227	Ac	261	Rf	262	Db	266	Sg	264	Bh	269	Hs	268	Mt																		
				Lanthanides																															
				Actinides																															

Lanthanides

Actinides