Topics in the June 2006 Exam Paper for CHEM1001

Click on the links for resources on each topic.

2006-J-2:

- Elements and Atoms
- Chemical Equations
- Stoichiometry
- Atomic Energy Levels

2006-J-3:

- Molecules and Ions
- Elements and Atoms

2006-J-4:

- Stoichiometry

2006-J-5:

- Stoichiometry

2006-J-6:

- Stoichiometry

2006-J-7:

- Thermochemistry
- First Law of Thermodynamics
- Chemical Equilibrium

2006-J-8:

- Introduction to Electrochemistry
- Electrochemistry

2006-J-9:

- Thermochemistry
- First Law of Thermodynamics
- Chemical Equations
- Stoichiometry

2006-J-10:

- Electrolytic Cells
- Introduction to Electrochemistry
- Electrochemistry
- Batteries and Corrosion

2006-J-11:

- Gas Laws

22/01(a)

The University of Sydney

FUNDAMENTALS OF CHEMISTRY 1A - CHEM1001

FIRST SEMESTER EXAMINATION

CONFIDENTIAL

JUNE 2006

TIME ALLOWED: THREE HOURS

GIVE THE FOLLOWING INFORMATION IN BLOCK LETTERS

FAMILY NAME		**SID NUMBER**	
OTHER NAMES		**TABLE NUMBER**	

INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 21 pages of examinable material.
- Complete the written section of the examination paper in **INK.**
- Read each question carefully. Report the appropriate answer and show all relevant working in the space provided.
- The total score for this paper is 100. The possible score per page is shown in the adjacent tables.
- Each new short answer question begins with a •.
- Electronic calculators, including programmable calculators, may be used. Students are warned, however, that credit may not be given, even for a correct answer, where there is insufficient evidence of the working required to obtain the solution.
- Numerical values required for any question, standard electrode reduction potentials, a Periodic Table and some useful formulas may be found on the separate data sheet.
- Pages 18 and 24 are for rough working only.

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Multiple choice section

	Marks	
Pages	Max	Gained
2-12	42	

Short answer section

Page	Marks Max	Gained		Marker
13	7			
14	8			
15	7			
16	3			
17	6			
19	7			
20	4			
21	4			
22	8			
23	4			
Total	58			
Check Total				

- Balance the following nuclear reactions by identifying the missing nuclear particle. **Marks 2**

$^{234}_{90}\text{Th} \rightarrow \square + {}^{0}_{-1}\text{e}$

$^{234}_{92}\text{U} \rightarrow \square + {}^{4}_{2}\text{He}$

- A nugget contains 2.6×10^{24} atoms of gold. What amount of gold (in mol) is in this nugget and what is its mass (in kg)? **2**

Amount: Mass:

- What element has the ground state electronic arrangement of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$? **1**

- A mobile phone sends signals at about 850 MHz (1 MHz = 1×10^6 Hz). What is the wavelength of this radiation? **2**

Wavelength =

- Account for why solid metals can conduct an electric current, but solid ionic compounds cannot.

Marks 3

- Complete the entries in the following table.

3

Element name	Symbol	Mass number	Atomic number	Number of electrons	Number of neutrons	$^{m}_{z}X$
lithium		7	3			
	Cu			29		$^{64}_{29}Cu$
aluminium			13		14	

- Give the formula and name of the binary compound formed from the following elements.

2

	Formula	Name
lithium and oxygen		
calcium and hydrogen		

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks 7

- The complete combustion of propane, C_3H_8, in air gives water and carbon dioxide as the products? Write a balanced equation for this reaction.

What mass of oxygen is required for the complete combustion of 454 g of propane and what masses of CO_2 and H_2O are produced?

Explain the "law of conservation of mass". Show whether or not the above combustion conforms to this law.

Marks 3

- The reaction of methane and water is one way to prepare hydrogen for use as a fuel.

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$$

Which compound is the limiting reactant if you begin with 995 g of methane and 2510 g of water?

Answer:

What mass of the excess reactant remains when the reaction is completed?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks

- An unknown compound contains carbon and hydrogen only. If 0.0956 g of the compound is burned in oxygen, 0.300 g of CO_2 and 0.123 g of H_2O are isolated. What is the unknown compound's empirical formula?

4

Answer:

If its molar mass is found to be 70.1 g mol^{-1}, what is its molecular formula?

Answer:

- What amount (in mol) of chloride ion is contained in 100 mL of 0.25 M magnesium chloride solution?

1

Answer:

- If 25.0 mL of 1.50 M hydrochloric acid is diluted to 500 mL, what is the molar concentration of the diluted acid?

1

Answer:

Marks

- A 1.00 g sample of ammonium nitrate, NH_4NO_3, is decomposed in a bomb calorimeter causing the temperature of the calorimeter to increase by 6.12 K. The heat capacity of the system is 1.23 kJ $°C^{-1}$. **3**

  Describe this process as either endothermic or exothermic.

  What is the molar heat of decomposition for ammonium nitrate?

Answer:

- Heating $SbCl_5$ causes it to decompose according to the following equation. **4**

$$SbCl_5(g) \rightleftharpoons SbCl_3(g) + Cl_2(g)$$

A sample of 0.50 mol of $SbCl_5$ is placed in a 1.0 L flask and heated to 450 ºC. When the system reaches equilibrium there is 0.10 mol of Cl_2 present. Calculate the value of the equilibrium constant, K_c, at 450 °C.

Answer:

Marks

- Consider a cell composed of the following half-reactions. **3**

$$Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq)$$

$$Cr(s) \rightarrow Cr^{3+}(aq) + 3e^-$$

What is the balanced equation for the spontaneous reaction?

What is the value of $E°$ for the cell? Relevant standard reduction potentials are on the data sheet.

Answer:

- What does the superscript "o" mean in the symbol $\Delta H_f°$? **1**

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks

- Calculate the standard heat of reaction for the following reaction. **2**

$$Zn(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Zn^{2+}(aq)$$

Data: $\Delta H^o_f = +64.4$ kJ mol^{-1} for $Cu^{2+}(aq)$

$\Delta H^o_f = -152.4$ kJ mol^{-1} for $Zn^{2+}(aq)$

Answer:

- Write a balanced **ionic** equation for the reaction of solid sodium hydrogencarbonate, $NaHCO_3$, and dilute sulfuric acid, H_2SO_4. **2**

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks

- Calculate the mass of silver nitrate, $AgNO_3$, required to make 500 mL of 0.200 M aqueous solution. **4**

Answer:

Calculate the time required (in minutes) to deposit 7.0 g of silver from a 0.200 M silver nitrate solution using a current of 4.5 A.

Answer:

- A lead-acid battery has the following shorthand notation: **4**

$Pb(s), PbSO_4(s) \mid H^+(aq), SO_4^{2-}(aq) \parallel H^+(aq), SO_4^{2-}(aq) \mid PbO_2(s), PbSO_4(s)$

Which component of the battery is the anode?

Give the balanced half equation of the reaction that takes place at the anode.

Which component of the battery is the cathode?

Give the balanced half equation of the reaction that takes place at the cathode.

- When "dry ice", solid carbon dioxide, is heated to 400 K it becomes gaseous. An 88.0 g sample of solid carbon dioxide is placed into a sealed 100 L container that is initially at a pressure of 1.00 atm and a temperature of 298 K. The container is heated to 400 K. What will be the final pressure inside the container?

Marks 4

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

CHEM1001 – FUNDAMENTALS OF CHEMISTRY 1A

DATA SHEET

Physical constants

Avogadro constant, $N_A = 6.022 \times 10^{23}$ mol^{-1}

Faraday constant, $F = 96485$ C mol^{-1}

Planck constant, $h = 6.626 \times 10^{-34}$ J s

Speed of light in vacuum, $c = 2.998 \times 10^{8}$ m s^{-1}

Rydberg constant, $E_R = 2.18 \times 10^{-18}$ J

Boltzmann constant, $k_B = 1.381 \times 10^{-23}$ J K^{-1}

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

$= 0.08206$ L atm K^{-1} mol^{-1}

Charge of electron, $e = 1.602 \times 10^{-19}$ C

Mass of electron, $m_e = 9.1094 \times 10^{-31}$ kg

Mass of proton, $m_p = 1.6726 \times 10^{-27}$ kg

Mass of neutron, $m_n = 1.6749 \times 10^{-27}$ kg

Properties of matter

Volume of 1 mole of ideal gas at 1 atm and 25 °C = 24.5 L

Volume of 1 mole of ideal gas at 1 atm and 0 °C = 22.4 L

Density of water at 298 K = 0.997 g cm^{-3}

Conversion factors

1 atm = 760 mmHg = 101.3 kPa

0 °C = 273 K

1 L = 10^{-3} m^3

1 Å = 10^{-10} m

1 eV = 1.602×10^{-19} J

1 Ci = 3.70×10^{10} Bq

1 Hz = 1 s^{-1}

Decimal fractions

Fraction	Prefix	Symbol
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Decimal multiples

Multiple	Prefix	Symbol
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G

CHEM1001 – FUNDAMENTALS OF CHEMISTRY 1A

Standard Reduction Potentials, E°

Reaction	*E*° / V
$Co^{3+}(aq) + e^- \rightarrow Co^{2+}(aq)$	+1.82
$Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq)$	+1.72
$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$	+1.50
$Cl_2 + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2 + 4H^+(aq) + 4e^- \rightarrow 2H_2O$	+1.23
$MnO_2(s) + 4H^+(aq) + e^- \rightarrow Mn^{3+} + 2H_2O$	+0.96
$Pd^{2+}(aq) + 2e^- \rightarrow Pd(s)$	+0.92
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$Cu^+(aq) + e^- \rightarrow Cu(s)$	+0.53
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	+0.15
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0 (by definition)
$Fe^{3+}(aq) + 3e^- \rightarrow Fe(s)$	–0.04
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	–0.13
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	–0.14
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.24
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$	–0.74
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$2H_2O + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	–0.83
$Cr^{2+}(aq) + 2e^- \rightarrow Cr(s)$	–0.89
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	–1.68
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.36
$Na^+(aq) + e^- \rightarrow Na(s)$	–2.71
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	–2.87
$Li^+(aq) + e^- \rightarrow Li(s)$	–3.04

CHEM1001 – FUNDAMENTALS OF CHEMISTRY 1A

Useful formulas

Quantum Chemistry

$E = h\nu = hc/\lambda$

$\lambda = h/mv$

$4.5k_BT = hc/\lambda$

$E = Z^2E_R(1/n^2)$

$\Delta x \cdot \Delta(mv) \geq h/4\pi$

$q = 4\pi r^2 \times 5.67 \times 10^{-8} \times T^4$

Electrochemistry

$\Delta G° = -nFE°$

Moles of $e^- = It/F$

$E = E° - (RT/nF) \times 2.303 \log Q$

$= E° - (RT/nF) \times \ln Q$

$E° = (RT/nF) \times 2.303 \log K$

$= (RT/nF) \times \ln K$

$E = E° - \frac{0.0592}{n} \log Q$ (at 25 °C)

Acids and Bases

$pK_w = pH + pOH = 14.00$

$pK_w = pK_a + pK_b = 14.00$

$pH = pK_a + \log\{[A^-] / [HA]\}$

Gas Laws

$PV = nRT$

$(P + n^2a/V^2)(V - nb) = nRT$

Colligative properties

$\pi = cRT$

$P_{solution} = X_{solvent} \times P°_{solvent}$

$p = kc$

$\Delta T_f = K_f m$

$\Delta T_b = K_b m$

Kinetics

$t_{½} = \ln 2/k$

$k = Ae^{-Ea/RT}$

$\ln[A] = \ln[A]_o - kt$

$\ln \frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

Radioactivity

$t_{½} = \ln 2/\lambda$

$A = \lambda N$

$\ln(N_0/N_t) = \lambda t$

^{14}C age $= 8033 \ln(A_0/A_t)$

Thermodynamics & Equilibrium

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta G = \Delta G° + RT \ln Q$

$\Delta G° = -RT \ln K$

$K_p = K_c (RT)^{\Delta n}$

Polymers

$R_g = \sqrt{\frac{nl_0^2}{6}}$

Mathematics

If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$\ln x = 2.303 \log x$

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 HYDROGEN **H** 1.008																	2 HELIUM **He** 4.003
3 LITHIUM **Li** 6.941	4 BERYLLIUM **Be** 9.012											5 BORON **B** 10.81	6 CARBON **C** 12.01	7 NITROGEN **N** 14.01	8 OXYGEN **O** 16.00	9 FLUORINE **F** 19.00	10 NEON **Ne** 20.18
11 SODIUM **Na** 22.99	12 MAGNESIUM **Mg** 24.31											13 ALUMINIUM **Al** 26.98	14 SILICON **Si** 28.09	15 PHOSPHORUS **P** 30.97	16 SULFUR **S** 32.07	17 CHLORINE **Cl** 35.45	18 ARGON **Ar** 39.95
19 POTASSIUM **K** 39.10	20 CALCIUM **Ca** 40.08	21 SCANDIUM **Sc** 44.96	22 TITANIUM **Ti** 47.88	23 VANADIUM **V** 50.94	24 CHROMIUM **Cr** 52.00	25 MANGANESE **Mn** 54.94	26 IRON **Fe** 55.85	27 COBALT **Co** 58.93	28 NICKEL **Ni** 58.69	29 COPPER **Cu** 63.55	30 ZINC **Zn** 65.39	31 GALLIUM **Ga** 69.72	32 GERMANIUM **Ge** 72.59	33 ARSENIC **As** 74.92	34 SELENIUM **Se** 78.96	35 BROMINE **Br** 79.90	36 KRYPTON **Kr** 83.80
37 RUBIDIUM **Rb** 85.47	38 STRONTIUM **Sr** 87.62	39 YTTRIUM **Y** 88.91	40 ZIRCONIUM **Zr** 91.22	41 NIOBIUM **Nb** 92.91	42 MOLYBDENUM **Mo** 95.94	43 TECHNETIUM **Tc** [98.91]	44 RUTHENIUM **Ru** 101.07	45 RHODIUM **Rh** 102.91	46 PALLADIUM **Pd** 106.4	47 SILVER **Ag** 107.87	48 CADMIUM **Cd** 112.40	49 INDIUM **In** 114.82	50 TIN **Sn** 118.69	51 ANTIMONY **Sb** 121.75	52 TELLURIUM **Te** 127.60	53 IODINE **I** 126.90	54 XENON **Xe** 131.30
55 CAESIUM **Cs** 132.91	56 BARIUM **Ba** 137.34	57-71	72 HAFNIUM **Hf** 178.49	73 TANTALUM **Ta** 180.95	74 TUNGSTEN **W** 183.85	75 RHENIUM **Re** 186.2	76 OSMIUM **Os** 190.2	77 IRIDIUM **Ir** 192.22	78 PLATINUM **Pt** 195.09	79 GOLD **Au** 196.97	80 MERCURY **Hg** 200.59	81 THALLIUM **Tl** 204.37	82 LEAD **Pb** 207.2	83 BISMUTH **Bi** 208.98	84 POLONIUM **Po** [210.0]	85 ASTATINE **At** [210.0]	86 RADON **Rn** [222.0]
87 FRANCIUM **Fr** [223.0]	88 RADIUM **Ra** [226.0]	89-103	104 RUTHERFORDIUM **Rf** [261]	105 DUBNIUM **Db** [262]	106 SEABORGIUM **Sg** [266]	107 BOHRIUM **Bh** [262]	108 HASSIUM **Hs** [265]	109 MEITNERIUM **Mt** [266]									

LANTHANIDES	57 LANTHANUM **La** 138.91	58 CERIUM **Ce** 140.12	59 PRASEODYMIUM **Pr** 140.91	60 NEODYMIUM **Nd** 144.24	61 PROMETHIUM **Pm** [144.9]	62 SAMARIUM **Sm** 150.4	63 EUROPIUM **Eu** 151.96	64 GADOLINIUM **Gd** 157.25	65 TERBIUM **Tb** 158.93	66 DYSPROSIUM **Dy** 162.50	67 HOLMIUM **Ho** 164.93	68 ERBIUM **Er** 167.26	69 THULIUM **Tm** 168.93	70 YTTERBIUM **Yb** 173.04	71 LUTETIUM **Lu** 174.97
ACTINIDES	89 ACTINIUM **Ac** [227.0]	90 THORIUM **Th** 232.04	91 PROTACTINIUM **Pa** [231.0]	92 URANIUM **U** 238.03	93 NEPTUNIUM **Np** [237.0]	94 PLUTONIUM **Pu** [239.1]	95 AMERICIUM **Am** [243.1]	96 CURIUM **Cm** [247.1]	97 BERKELLIUM **Bk** [247.1]	98 CALIFORNIUM **Cf** [252.1]	99 EINSTEINIUM **Es** [252.1]	100 FERMIUM **Fm** [257.1]	101 MENDELEVIUM **Md** [256.1]	102 NOBELIUM **No** [259.1]	103 LAWRENCIUM **Lr** [260.1]