Topics in the June 2008 Exam Paper for CHEM1001

Click on the links for resources on each topic.

2008-J-2:

- Elements and Atoms

2008-J-3:

- Lewis Model of Bonding
- VSEPR

2008-J-4:

- Atomic Energy Levels
- Lewis Model of Bonding

2008-J-5:

- Stoichiometry

2008-J-6:

- Stoichiometry

2008-J-8:

- Gas Laws
- Chemical Equilibrium

2008-J-9:

- First Law of Thermodynamics
- Chemical Equilibrium

2008-J-10:

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

2008-J-11:

- First Law of Thermodynamics
- Thermochemistry
- Types of Intermolecular Forces

2008-J-12:

- First Law of Thermodynamics
- Oxidation Numbers
- Nitrogen Chemistry and Compounds

22/01(a) The University of Sydney

FUNDAMENTALS OF CHEMISTRY 1A - CHEM1001

FIRST SEMESTER EXAMINATION

CONFIDENTIAL

JUNE 2008 **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 20 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 17, 21 and 24 are for rough working only.

OFFICIAL USE ONLY

Multiple choice section

	Marks	
Pages	Max	Gained
2-10	32	

Short answer section

	Marks			
Page	Max	Gained		Marker
11	6			
12	9			
13	7			
14	6			
15	6			
16	4			
18	6			
19	5			
20	7			
22	6			
23	6			
Total	68			
Check Total				

Marks

- Write balanced equations for the following nuclear reactions. **4**

Nickel-63 undergoes beta decay to become a stable nuclide.	
An alpha particle is produced from the decay of radon-222.	

- Direct damage to the DNA of skin cells can be brought about by exposure to ultraviolet radiation of wavelength 300.0 nm. What are the frequency and energy of this radiation? **2**

Frequency:	Energy:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

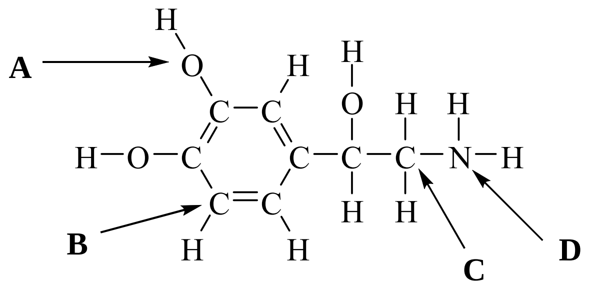
Marks
9

- Complete the following table.

Molecular formula	NH_3	PCl_5	BrF_3
Name			
Lewis structure			
Number of bonding electron pairs on central atom			
Number of non-bonding electron pairs on central atom			
Molecular shape			

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

	Marks
• What is the ground state electron configuration for the chlorine atom?	2
• Briefly explain the concept of resonance. Give at least one example.	2
• The structure of adrenaline is shown below.	3



Give the approximate bond angles at the indicated atoms.

A:	**B**:	**C**:	**D**:

Which, if any, of the indicated atoms has at least one lone pair of electrons?

Marks

- What mass of oxygen is required for the complete combustion of 5.8 g of butane, C_4H_{10}. How many moles of CO_2 and H_2O are produced? **4**

- A white powder used in paints, enamels and ceramics has the following mass percentage: 69.6% Ba; 6.09% C; 24.3% O. What is its empirical formula? **2**

Answer:

Marks
6

- Lead(II) iodide precipitates when 0.080 M lead(II) nitrate solution (150.0 mL) is added to 0.080 M potassium iodide solution (50.0 mL). Write a balanced ionic equation for the reaction that occurs.

What amount (in mol) of lead(II) iodide precipitates?

Answer:

What amount (in mol) of Pb^{2+}(aq) ions remain in solution after the reaction?

Answer:

What is the final concentration of NO_3^-(aq) ions remaining in solution after the reaction?

Answer:

Marks
4

- Cadmium chloride and cadmium sulfate are both soluble in water. Cadmium carbonate and cadmium hydroxide are both insoluble. Describe, using equations where appropriate, how to convert cadmium chloride into cadmium sulfate.

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks
6

- Ammonia, NH_3, is produced from nitrogen and hydrogen gas at high temperatures using the Haber process. At a temperature of 670 K and 50.0 MPa pressure, an equilibrium mixture was found to contain 0.925 mol nitrogen, 2.775 mol hydrogen and 1.50 mol ammonia. Write a balanced equation for the Haber process.

Calculate the mole fraction of each gas in the mixture.

Calculate the partial pressure of each gas.

Calculate the value for K_p for the reaction at this temperature.

Answer:

Marks

- The dissociation of gaseous N_2O_4 to NO_2 in the upper atmosphere occurs according to the following equation. **2**

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad K_p = 0.106 \text{ at } 1800 \text{ K.}$$

What is the free energy change (in kJ mol^{-1}) for this reaction?

Answer:

- A sample of 0.62 mol CCl_4 was placed in a 2.0 L container and heated to a certain temperature. At equilibrium, $[Cl_2]$ = 0.060 M. What is the value of the equilibrium constant K_c for the following reaction at that temperature? **3**

$$CCl_4(g) \rightleftharpoons C(s) + 2Cl_2(g)$$

Answer:

Marks

- A galvanic cell consists of a Cu^{2+}(aq)/Cu(s) and a Ag^{+}(aq)/Ag(s) half cell. If the voltage of the cell is 0.35 V and the concentration of Cu^{2+}(aq) is 3.5 M, what is the concentration of Ag^{+}(aq)? **2**

Answer:

- How many minutes will be required for a 1.50 A current to electroplate 1.97 g of gold from a solution containing $AuCl_4^-$ ions? **2**

Answer:

- A solar powered light uses a nickel-cadmium battery to store electricity. Calculate the standard voltage for the battery from the following: **3**

$NiO_2(s) + Cd(s) + 2H_2O(l) \rightarrow Ni(OH)_2(s) + Cd(OH)_2 \quad \Delta G^o = -251 \text{ kJ mol}^{-1}$

Answer:

Marks

- The conversion of SO_2 to SO_3 can occur in the catalytic converters of cars using gasoline containing traces of sulfur compounds. Calculate the enthalpy change of the following reaction. **2**

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

Data: $S(s) + O_2(g) \rightarrow SO_2(g)$ $\Delta H = -296.8 \text{ kJ mol}^{-1}$

$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$ $\Delta H = -791.4 \text{ kJ mol}^{-1}$

Answer:

- If 78.2 J is required to raise the temperature of 45.6 g of lead by 13.3 °C, what is the specific heat of lead in J g^{-1} K^{-1}? **1**

Answer:

- Rank the following compounds in order of increasing boiling point? Justify your answer. **3**

$CH_3CH_2OCH_2CH_3$, CH_3OH, CH_4, CH_3CH_3, CH_3CH_2OH

Marks
6

- When a 1.00 g sample of carbon is burnt in a calorimeter to produce CO_2(g), a temperature rise of 6.66 ºC is observed. When a 1.00 g sample of solid NH_4NO_3 is decomposed in the same calorimeter, a temperature rise of 0.300 ºC is observed. The equation for this reaction is:

$$2NH_4NO_3(s) \rightarrow 2N_2(g) + 4H_2O(g) + O_2(g)$$

What is the heat of reaction for the decomposition of 1.00 kg of ammonium nitrate?

Heat of formation data: $\Delta_f H = -393.3$ kJ mol^{-1} for CO_2(g)

Answer:

List all of the nitrogen containing species in this reaction. Beside each, give the oxidation number of the nitrogen in that species.

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}

Permittivity of a vacuum, $\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 J^{-1} m^{-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}

1 tonne = 10^3 kg

1 W = 1 J 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
$MnO_4^{-}(aq) + 8H^{+}(aq) + 5e^{-} \rightarrow Mn^{2+}(aq) + 4H_2O$	+1.51
$Au^{3+}(aq) + 3e^{-} \rightarrow Au(s)$	+1.50
$Cl_2 + 2e^{-} \rightarrow 2Cl^{-}(aq)$	+1.36
$O_2 + 4H^{+}(aq) + 4e^{-} \rightarrow 2H_2O$	+1.23
$Pt^{2+}(aq) + 2e^{-} \rightarrow Pt(s)$	+1.18
$MnO_2(s) + 4H^{+}(aq) + e^{-} \rightarrow Mn^{3+} + 2H_2O$	+0.96
$NO_3^{-}(aq) + 4H^{+}(aq) + 3e^{-} \rightarrow NO(g) + 2H_2O$	+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
$Cd^{2+}(aq) + 2e^{-} \rightarrow Cd(s)$	–0.40
$Fe^{2+}(aq) + 2e^{-} \rightarrow Fe(s)$	–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

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

$\lambda = h/mv$

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

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

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

$4.5k_BT = hc/\lambda$

$T = 2.898 \times 10^6/\lambda(\text{nm})$

Electrochemistry

$\Delta G° = -nFE°$

Moles of $e^- = It/F$

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

$\quad = E° - (RT/nF) \times \ln Q$

$E° = (RT/nF) \times 2.303 \log K$

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

$E = E° - \frac{0.0592}{n} \log Q$ (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

$\pi = cRT$

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

$p = kc$

$\Delta T_f = K_fm$

$\Delta T_b = K_bm$

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 = $8033 \ln(A_0/A_t)$ years

Thermodynamics & Equilibrium

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta G = \Delta G° + RT \ln Q$

$\Delta G° = -RT \ln K$

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

Miscellaneous

$A = -\log\frac{I}{I_0}$

$A = \varepsilon cl$

$E = -A\frac{e^2}{4\pi\varepsilon_0 r}N_A$

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]	110 DARMSTADTIUM **Ds** [271]	111 ROENTGENIUM **Rg** [272]							

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]