Topics in the November 2009 Exam Paper for CHEM1612

Click on the links for resources on each topic.

2009-N-2:

- Introduction to Chemical Energetics

2009-N-3:

- Solutions
- Gas Laws

2009-N-4:

- Acids and Bases

2009-N-5:

- Chemical Equilibrium

2009-N-6:

- Introduction to Chemical Energetics
- Gas Laws
- Chemical Equilibrium

2009-N-7:

- Complexes

2009-N-8:

- Solubility
- Introduction to Chemical Energetics

2009-N-9:

- Chemical Kinetics

2009-N-10:

- Radiochemistry

2009-N-11:

- Introduction to Colloids and Surface Chemistry
- Solubility

2009-N-12:

- Chemical Equilibrium

2009-N-13:

- Complexes

2009-N-14:

- Introduction to Colloids and Surface Chemistry
- Chemical Kinetics

2009-N-15:

- Redox Reactions and Introduction to Electrochemistry

2009-N-16:

- Chemical Equilibrium
- Redox Reactions and Introduction to Electrochemistry
- Complexes

22/32(a) **The University of Sydney**

CHEM1612 - CHEMISTRY 1B (PHARMACY)

SECOND SEMESTER EXAMINATION

CONFIDENTIAL

NOVEMBER 2009 **TIME ALLOWED: THREE HOURS**

GIVE THE FOLLOWING INFORMATION IN BLOCK LETTERS

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

OFFICIAL USE ONLY

Multiple choice section

	Marks	
Pages	Max	Gained
2-7	20	

Short answer section

Page	Marks Max	Gained		Marker
8	4			
9	6			
10	4			
12	3			
13	5			
14	4			
15	6			
16	6			
17	6			
18	8			
19	3			
20	6			
21	5			
22	5			
23	9			
Total	80			

INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 21 pages of examinable material.
- Complete 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 question of the short answer section 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 sheets.
- Pages 11 and 24 are for rough working only.

Marks
4

- Nitroglycerine, $C_3H_5(NO_3)_3$, decomposes to form N_2, O_2, CO_2 and H_2O according to the following equation.

$$4C_3H_5(NO_3)_3(l) \rightarrow 6N_2(g) + O_2(g) + 12CO_2(g) + 10H_2O(g)$$

If 15.6 kJ of energy is evolved by the decomposition of 2.50 g of nitroglycerine at 1 atm and 25 °C, calculate the enthalpy change, $\Delta H°$, for the decomposition of 1.00 mol of this compound under standard conditions.

Answer:

Hence calculate the enthalpy of formation of nitroglycerine under standard conditions.

Data:

	$\Delta_f H°$ (kJ mol^{-1})
$H_2O(g)$	–242
$CO_2(g)$	–394

Answer:

Marks

- Assuming ideal behaviour, calculate the mass of $MgCl_2 \cdot 6H_2O$ that should be dissolved in 1.0 L of water at 37 ºC to obtain a solution with an osmotic pressure of 6.0 atm, the same as that of cell cytoplasm. **4**

Answer:

- The average speed of a gaseous neon atom at 300 K is 609 m s^{-1}. What is the average speed of a helium atom at the same temperature? **2**

Answer:

Marks

- Tris(hydroxymethyl)aminomethane is commonly used to make buffer solutions. It has a base ionisation constant of 1.26×10^{-6}. What is the pH of a 0.05 M aqueous solution of this compound? **3**

Answer:

- The ionisation constant of water, K_w, at 37 °C is 2.42×10^{-14}. What is the pH for a neutral solution at 37 °C? **1**

Answer:

Marks 3

- Consider the following reaction.

$$H_2O(g) + Cl_2O(g) \rightleftharpoons 2HOCl(g) \qquad K_p = 0.090 \text{ at } 298 \text{ K}$$

Calculate $\Delta G°$ (in J mol^{-1}) for this reaction.

$\Delta G° =$

Calculate ΔG (in J mol^{-1}) at 25 °C when $p(H_2O)$ = 18 mmHg, $p(Cl_2O)$ = 2.0 mmHg and $p(HOCl)$ = 0.10 mmHg.

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks

Explain the following terms or concepts. **3**

a) Lewis acid

b) 3rd Law of Thermodynamics

c) Brownian motion

- $\Delta_{vap}H°$ = 34.0 kJ mol^{-1} for benzene, which has a boiling point of 80.1 °C. What is the entropy change for the vaporisation of benzene in J K^{-1} mol^{-1}? **2**

Answer:

Marks
4

- The general formula for a nickel(II) chloride compound complexed with ammonia is $[Ni(NH_3)_x]Cl_2$. A 0.59 g sample of the salt was dissolved in water and the ammonia from it was titrated with 153 mL of 0.100 M HCl. What is the value of the coefficient *x*?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks

- Will AgCl precipitate if solutions of 25.0 mL of 2.0×10^{-5} M KCl and 75.0 mL of 1×10^{-5} M $AgNO_3$ are added to one another? Show your reasoning. K_{sp} for AgCl = 1.8×10^{-10} at 25 °C. **2**

Answer:

- A mass of 1.250 g of benzoic acid ($C_7H_6O_2$) underwent combustion in a bomb calorimeter. If the heat capacity of the calorimeter was 10.134 kJ K^{-1} and the heat of combustion of benzoic acid is –3226 kJ mol^{-1}, what is the change in internal energy during this reaction? **4**

Answer:

Calculate the temperature change that should have occurred in the apparatus.

Answer:

Marks
6

- The disproportionation of hydrogen peroxide into oxygen and water has an enthalpy of reaction of –98.2 kJ mol^{-1} and an activation barrier of 75 kJ mol^{-1}. Iodide ions act as a catalyst for this reaction, with an activation barrier of 56 kJ mol^{-1}. The enzyme, catalase, is also a catalyst for this reaction, and this pathway has an activation barrier of 23 kJ mol^{-1}. Draw a labelled potential energy diagram for this process both without and with each of the catalysts.

Calculate the factor by which the reaction speeds up due to the presence of each of these two catalysts at a temperature of 37 °C. Assume that the pre-exponential Arrhenius factor remains constant.

Marks

- A medical procedure requires 15.0 mg of ^{111}In. What mass of isotope would be required to be able to use it exactly 4 days later? The half life of ^{111}In is 2.80 days. **2**

Answer:

- Write balanced nuclear equations for the following reactions. **3**

  Positron decay of potassium-40.

  Electron capture by gallium-67.

  Alpha decay of dysprosium-151.

- Briefly explain the apparent contradiction between the following statements. **1**

  "Alpha particles are easily stopped by the skin."
  "The alpha-emitter, radon, is thought to be a significant cause of cancer."

Marks

- Give 2 examples of changes of conditions that might cause a colloidal dispersion to coagulate. In each case, explain why coagulation occurs. **4**

- A saturated solution of lithium carbonate in pure water at 20 °C contains 1.33 g of solute per 100.0 mL of solution. Calculate the aqueous solubility product of lithium carbonate at this temperature. **4**

K_{sp} =

When the temperature of the same solution is raised to 40 °C, the solubility is reduced to 1.17 g per 100.0 mL of solution. What conclusions can be drawn about the sign of the standard enthalpy of dissolution of lithium carbonate?

Marks
3

- A mixture of NaCl (5.0 g) and $AgNO_3$ (5.0 g) was added to 1.0 L of water. What are the concentrations of Ag^+(aq), Cl^-(aq) and Na^+(aq) ions in solution after equilibrium has been established? K_{sp}(AgCl) = 1.8×10^{-10}.

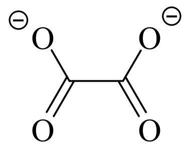
$[Ag^+(aq)]$ =	$[Cl^-(aq)]$ =	$[Na^+(aq)]$ =

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks

- Can methane act as a ligand? Explain your answer. **2**

- Fe(II) generally forms octahedral complexes. How many different complex ions can be formed when $Fe(NO_3)_2$ is dissolved in an aqueous solution of sodium oxalate? The structure of the oxalate ligand is shown below. **4**



Answer:

Draw diagrams of any 3 of these complexes, including at least one that is chiral.

Marks

- Explain how the self-assembly of phospholipids can be utilised in a drug delivery system. **2**

- A proposed kinetic model for the reaction of NO(g) with Br_2(g) to form NOBr(g) is as follows. **3**

Step 1 $$NO(g) + NO(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} N_2O_2(g)$$

Step 2 $$N_2O_2(g) + Br_2(g) \xrightarrow{k_2} 2NOBr(g)$$

If Step 2 is assumed to be very slow compared to the equilibrium of Step 1, derive the overall rate equation you would expect to see for this mechanism.

Marks

- The standard reduction potential of phosphorous acid to hypophosphorous acid is −0.499 V, with the following half-reaction: **3**

$$H_3PO_3(aq) + 2H^+(aq) + 2e^- \rightarrow H_3PO_2(aq) + H_2O(l)$$

What would the reduction potential be for this half reaction at a temperature of 25 °C in an aqueous solution with pH of 2.3 and concentrations of $[H_3PO_3(aq)]$ = 0.37 M and $[H_3PO_2(aq)]$ = 0.00025 M?

Answer:

- A number of bacteria can reduce the nitrate ion in the presence of sulfur. A simplified unbalanced redox reaction can be written as: **2**

$$S(s) + NO_3^-(aq) \rightarrow SO_2(g) + NO(g)$$

Balance this redox equation for acidic conditions.

Marks

- What is the value of the equilibrium constant for the following reaction at 298 K? **3**

$$2Fe^{3+}(aq) + 3Sn(s) \rightarrow 2Fe(s) + 3Sn^{2+}(aq)$$

Relevant electrode potentials can be found on the data page.

Answer:

- Complete the following table. **4**

Formula	Systematic name
$[CrCl(NH_3)_5]Cl_2$	
	dibromidotetracarbonylplatinum(IV) nitrite
$K_3[CrF_6]$	
$(NH_4)_3[CuF_5(OH_2)]$	

- State two chemical factors that contribute to the bioavailability of a heavy metal in the human body. **2**

CHEM1612 - CHEMISTRY 1B (PHARMACY)

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 Pa = 1 N m^{-2} = 1 kg m^{-1} s^{-2}

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
10^{12}	tera	T

CHEM1612 - CHEMISTRY 1B (PHARMACY)

Standard Reduction Potentials, *E*°

Reaction	*E*° / V
$S_2O_8^{2-}$ + $2e^-$ → $2SO_4^{2-}$	+2.01
$Co^{3+}(aq)$ + e^- → $Co^{2+}(aq)$	+1.82
$Ce^{4+}(aq)$ + e^- → $Ce^{3+}(aq)$	+1.72
$MnO_4^-(aq)$ + $8H^+(aq)$ + $5e^-$ → $Mn^{2+}(aq)$ + $4H_2O$	+1.51
$Au^{3+}(aq)$ + $3e^-$ → Au(s)	+1.50
$Cl_2(g)$ + $2e^-$ → $2Cl^-(aq)$	+1.36
$O_2(g)$ + $4H^+(aq)$ + $4e^-$ → $2H_2O$	+1.23
Br_2 + $2e^-$ → $2Br^-(aq)$	+1.10
$MnO_2(s)$ + $4H^+(aq)$ + e^- → $Mn^{3+}(aq)$ + $2H_2O$	+0.96
$NO_3^-(aq)$ + $4H^+(aq)$ + $3e^-$ → NO(g) + $2H_2O$	+0.96
$Pd^{2+}(aq)$ + $2e^-$ → Pd(s)	+0.92
$Ag^+(aq)$ + e^- → Ag(s)	+0.80
$Fe^{3+}(aq)$ + e^- → $Fe^{2+}(aq)$	+0.77
$I_2(aq)$ + $2e^-$ → $2I^-(aq)$	+0.62
$Cu^+(aq)$ + e^- → Cu(s)	+0.53
$Cu^{2+}(aq)$ + $2e^-$ → Cu(s)	+0.34
$Sn^{4+}(aq)$ + $2e^-$ → $Sn^{2+}(aq)$	+0.15
$2H^+(aq)$ + $2e^-$ → $H_2(g)$	0 (by definition)
$Fe^{3+}(aq)$ + $3e^-$ → Fe(s)	–0.04
$Pb^{2+}(aq)$ + $2e^-$ → Pb(s)	–0.13
$Sn^{2+}(aq)$ + $2e^-$ → Sn(s)	–0.14
$Ni^{2+}(aq)$ + $2e^-$ → Ni(s)	–0.24
$Co^{2+}(aq)$ + $2e^-$ → Co(s)	–0.28
$Fe^{2+}(aq)$ + $2e^-$ → Fe(s)	–0.44
$Cr^{3+}(aq)$ + $3e^-$ → Cr(s)	–0.74
$Zn^{2+}(aq)$ + $2e^-$ → Zn(s)	–0.76
$2H_2O$ + $2e^-$ → $H_2(g)$ + $2OH^-(aq)$	–0.83
$Cr^{2+}(aq)$ + $2e^-$ → Cr(s)	–0.89
$Al^{3+}(aq)$ + $3e^-$ → Al(s)	–1.68
$Mg^{2+}(aq)$ + $2e^-$ → Mg(s)	–2.36
$Na^+(aq)$ + e^- → Na(s)	–2.71
$Ca^{2+}(aq)$ + $2e^-$ → Ca(s)	–2.87
$Li^+(aq)$ + e^- → Li(s)	–3.04

CHEM1612 - CHEMISTRY 1B (PHARMACY)

Useful formulas

Quantum Chemistry	**Electrochemistry**
$E = h\nu = hc/\lambda$ $\lambda = h/mv$ $E = -Z^2E_R(1/n^2)$ $\Delta x \cdot \Delta(mv) \geq h/4\pi$ $q = 4\pi r^2 \times 5.67 \times 10^{-8} \times T^4$ $T\lambda = 2.898 \times 10^6$ K nm	$\Delta G° = -nFE°$ *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	**Gas Laws**
$pK_w = pH + pOH = 14.00$ $pK_w = pK_a + pK_b = 14.00$ $pH = pK_a + \log\{[A^-] / [HA]\}$	$PV = nRT$ $(P + n^2a/V^2)(V - nb) = nRT$ $E_k = ½mv^2$
Radioactivity	**Kinetics**
$t_{½} = \ln 2/\lambda$ $A = \lambda N$ $\ln(N_0/N_t) = \lambda t$ ^{14}C age = 8033 $\ln(A_0/A_t)$ years	$t_{½} = \ln 2/k$ $k = Ae^{-Ea/RT}$ $\ln[A] = \ln[A]_o - kt$ $\ln \frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$
Colligative Properties and Solutions	**Thermodynamics and Equilibrium**
$\Pi = cRT$ $P_{solution} = X_{solvent} \times P°_{solvent}$ $c = kp$ $\Delta T_f = K_f m$ $\Delta T_b = K_b m$	$\Delta G° = \Delta H° - T\Delta S°$ $\Delta G = \Delta G° + RT \ln Q$ $\Delta G° = -RT \ln K$ $\Delta_{univ}S° = R \ln K$ $K_p = K_c (RT)^{\Delta n}$
Miscellaneous	**Mathematics**
$A = -\log \frac{I}{I_0}$ $A = \varepsilon cl$ $E = -A \frac{e^2}{4\pi\varepsilon_0 r} N_A$	If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ $\ln x = 2.303 \log x$ Area of circle = πr^2 Surface area of sphere = $4\pi r^2$

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]							

LANTHANOIDS	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
ACTINOIDS	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]