Topics in the November 2012 Exam Paper for CHEM1612

Click on the links for resources on each topic.

2012-N-2:

- Introduction to Chemical Energetics
- Solutions
- Acids and Bases
- Chemical Equilibrium

2012-N-3:

- Introduction to Chemical Energetics

2012-N-4:

- Gas Laws

2012-N-5:

- Chemical Equilibrium

2012-N-6:

- Acids and Bases
- Solutions

2012-N-7:

- Introduction to Chemical Energetics
- Solutions

2012-N-8:

- Acids and Bases

2012-N-9:

- Solutions
- Complexes

2012-N-10:

- Radiochemistry

2012-N-11:

- Redox Reactions and Introduction to Electrochemistry

2012-N-12:

- Redox Reactions and Introduction to Electrochemistry
- Chemical Kinetics

2012-N-13:

- Redox Reactions and Introduction to Electrochemistry
- Introduction to Colloids and Surface Chemistry

2012-N-14:

- Complexes

2012-N-15:

- Chemical Kinetics

2218(a)

THE UNIVERSITY OF SYDNEY

CHEM1612 - CHEMISTRY 1B (PHARMACY)

SECOND SEMESTER EXAMINATION

CONFIDENTIAL

NOVEMBER 2012 **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 22 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 short answer question begins with a •.
- Only non-programmable, University-approved calculators may be used.
- Students are warned 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.
- Page 24 is for rough work only.

OFFICIAL USE ONLY

Multiple choice section

	Marks	
Pages	Max	Gained
2-9	28	

Short answer section

Page	Marks Max	Gained		Marker
10	6			
11	4			
12	3			
13	4			
14	5			
15	7			
16	4			
17	7			
18	5			
19	6			
20	5			
21	6			
22	6			
23	4			
Total	72			
Check Total				

Marks

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

a) Second law of thermodynamics

b) Vapour pressure

c) Isoelectric point

- The electron transfer reaction between NADH and oxygen is a spontaneous reaction at 37 °C **3**

$$NADH + \tfrac{1}{2}O_2 + H^+ \rightarrow NAD^+ + H_2O \qquad \Delta G = -220 \text{ kJ mol}^{-1}$$

When this reaction is carried out in solution in a test tube via direct mixing of NADH with dissolved oxygen, the reaction releases a significant amount of heat. However, when the reaction occurs in mitochondria during respiration, it produces very little heat. Explain why the heat evolved is much less in mitochondria.

Marks

- Copper metal can be obtained by heating copper oxide , CuO, in the presence of carbon monoxide, CO, according to the following reaction. **2**

$$CuO(s) + CO(g) \rightarrow Cu(s) + CO_2(g)$$

Calculate $\Delta H°$ for this reaction in kJ mol^{-1}.

Data: $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$ $\Delta H° = -566.1$ kJ mol^{-1}

$2Cu(s) + O_2(g) \rightarrow 2CuO(s)$ $\Delta H° = -310.5$ kJ mol^{-1}

Answer:

- Acetylene burns in air according to the following equation: **2**

$$C_2H_2(g) + {}^5/_2O_2(g) \rightarrow 2CO_2(g) + H_2O(g) \qquad \Delta H° = -1255.8 \text{ kJ mol}^{-1}$$

The $\Delta_fH°$ of $CO_2(g) = -393.5$ kJ mol^{-1}, $\Delta_fH°$ of $H_2O(l) = -285.8$ kJ mol^{-1} and $\Delta_{vap}H°$ of $H_2O(l) = +44.0$ kJ mol^{-1}. What is $\Delta_fH°$ of $C_2H_2(g)$?

Answer:

Page Total:

Marks
3

- A sample of gas is found to exert a pressure of 7.00×10^4 Pa when it is in a 3.00 L flask at 10.00 °C. Calculate the new volume if the pressure becomes 1.01×10^5 Pa and the temperature is unchanged.

Answer:

Calculate the new pressure if the volume becomes 2.00 L and the temperature is unchanged.

Answer:

Calculate the new pressure if the temperature is raised to 50.0 °C and the volume is unchanged, *i.e.* still 3.00 L.

Answer:

Marks 4

- Consider the following reaction.

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

An equilibrium mixture in a 1.00 L vessel was found to contain $[SO_2(g)] = 0.800$ M, $[NO_2(g)] = 0.100$ M, $[SO_3(g)] = 0.600$ M and $[NO(g)] = 0.400$ M. If the volume and temperature are kept constant, what amount (in mol) of NO(g) needs to be added to the reaction vessel to give an equilibrium concentration of $NO_2(g)$ of 0.300 M?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks

- Phenylketonuria is an inherited disorder in which phenylacetic acid, $C_6H_5CH_2COOH$, (simplified here to HPAc) accumulates in the blood. If untreated, it can cause mental retardation and death. A study of the acid shows that the pH of a 0.12 M HPAc solution is 2.60. What is the pK_a of phenylacetic acid? **3**

Answer:

- The concentration of NaCl used in intravenous drips is 150 mM. Explain why this particular concentration is used and what the consequences would be for a patient if pure water were used instead. **2**

Marks

- A calorimeter, consisting of an insulated coffee cup containing 50.0 g of water at 21.0 °C, has a total heat capacity of 9.4 J K^{-1}. When a 30.4 g sample of an alloy at 92.0 °C is placed into the calorimeter, the final temperature of the system is 31.2 °C. What is the specific heat capacity of the alloy? **3**

Answer:

- At 21.0 °C, a solution of 18.26 g of a non-volatile, non-polar compound in 33.25 g of bromoethane, CH_3CH_2Br, has a vapour pressure of 4.42×10^4 Pa. The vapour pressure of pure bromoethane at this temperature is 5.26×10^4 Pa. What is the molar mass of the compound? **4**

Answer:

Marks
4

- Buffer 1 is a solution containing 0.08 M NH_4Cl and 0.12 M NH_3. Buffer 2 is a solution containing 0.15 M NH_4Cl and 0.05 M NH_3. The acid dissociation constant of the ammonium ion is 5.50×10^{-10}. What are the pH values of each of the buffer solutions?

Buffer 1 pH =	Buffer 2 pH =

Which buffer is better able to maintain a steady pH on the addition of small amounts of both a strong acid and strong base? Explain.

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks

4

- Order the following salts from lowest to highest molar solubility.

Salt	CuCl	$Cd(IO_3)_2$	$BaSO_4$	Ag_2CrO_4
K_{sp}	1.9×10^{-7}	2.3×10^{-8}	1.1×10^{-10}	2.6×10^{-12}

3

- Give the equilibrium concentration of $Ni^{2+}(aq)$ ions in a solution formed by dissolving 0.15 mol of $NiCl_2$ in 0.500 L of 2.00 M KCN solution.
  The K_{stab} of $[Ni(CN)_4]^{2-} = 1.7 \times 10^{30}$.

Answer:

Marks

- What mass of isotope would be initially required if a medical procedure needs 2.0 mg of ^{99m}Tc exactly 50 hours later? The half life of ^{99m}Tc is 6.0 hours. **2**

Answer:

- Comment on the stability of the following nuclides, and the type of radioactive decay (if any) that they undergo. **3**

$^{18}_{10}$Ne

$^{32}_{16}$S

$^{236}_{90}$Th

Page Total:

Marks 6

- A galvanic cell consists of a Cr^{3+}/Cr half-cell with unknown [Cr^{3+}] and a Ni^{2+}/Ni half-cell with [Ni^{2+}] = 1.20 M. The electromotive force of the cell at 25 °C was measured to be 0.55 V. What is the concentration of Cr^{3+} in the Cr^{3+}/Cr half-cell?

Answer:

Calculate the equilibrium constant of the reaction at 25 °C.

Answer:

Calculate the standard Gibbs free energy of the reaction at 25 °C.

Answer:

Express the overall reaction in the shorthand voltaic cell notation.

Marks

3

- A strip of copper and a strip of zinc are embedded in a lemon, and are connected by wires to a voltmeter; a voltage is generated and can be read at the voltmeter. What chemical reactions are occurring that lead to the generation of current?

Assuming there are no losses in the circuit and the conditions are similar to standard, what voltage can be read at the voltmeter?

2

- The rate constant of a polymer cross-linking reaction was established as a function of temperature. How can we demonstrate that the kinetics of this reaction follow Arrhenius behaviour? If it does follow Arrhenius behaviour, how can we derive the activation energy for the reaction and the pre-exponential factor *A*?

Page Total:

	Marks
• A 20.0 mL sample of 0.121 M Fe^{2+} in an acid solution was used to titrate 23.5 mL of a $KMnO_4$ solution of unknown concentration. Write the balanced redox reaction that occurs in solution upon titration, and calculate the molarity of the $KMnO_4$ solution.	4

Answer:

• Why do phospholipids self-assemble in solution, what structures do they form, and why are they relevant to cell biology?	2

Marks

- Draw all stereoisomers of the complex ion of $[CoCl_2(en)_2]Cl$. Label the non-optically active isomer with its systematic name.
(en = ethylenediamine = 1,2-ethanediamine = $NH_2CH_2CH_2NH_2$) **4**

- What is a dative bond and does it differ from a covalent bond? Use examples from coordination chemistry and elsewhere to illustrate your answer. **2**

Marks 4

- The major pollutants emitted by cars, NO(g), CO(g), NO_2(g) and CO_2(g), can react according to the following equation.

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$$

The following rate data were collected at 215 °C.

Experiment	$[NO_2]_0$ (M)	$[CO]_0$ (M)	Initial rate ($d[NO_2]/dt$, M s^{-1})
1	0.263	0.826	1.44×10^{-5}
2	0.263	0.413	1.44×10^{-5}
3	0.526	0.413	5.76×10^{-5}

Determine the rate law for the reaction.

Suggest a possible mechanism for the reaction based on the form of the rate law. Explain your answer.

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 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

CHEM1612 - CHEMISTRY 1B (PHARMACY)

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
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(g) + 7H_2O$	+1.36
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O$	+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
$Sc^{3+}(aq) + 3e^- \rightarrow Sc(s)$	–2.09
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–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

CHEM1612 - CHEMISTRY 1B (PHARMACY)

Useful formulas

Quantum Chemistry $E = h\nu = hc/\lambda$ $\lambda = h/mv$ $E = -Z^2E_R(1/n^2)$ $\Delta x \cdot \Delta(mv) \geq h/4\pi$ $q = 4\pi r^2 \times 5.67 \times 10^{-8} \times T^4$ $T\lambda = 2.898 \times 10^6$ K nm	**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** $PV = nRT$ $(P + n^2a/V^2)(V - nb) = nRT$ $E_k = ½mv^2$
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	**Kinetics** $t_{½} = \ln 2/k$ $k = Ae^{-Ea/RT}$ $\ln[A] = \ln[A]_o - kt$ $\ln\frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$
Mathematics 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 = $4\pi r^2$ Volume of sphere = $^4/_3\ \pi r^3$	**Thermodynamics & Equilibrium** $\Delta G° = \Delta H° - T\Delta S°$ $\Delta G = \Delta G° + RT \ln Q$ $\Delta G° = -RT \ln K$ $\Delta_{univ}S° = R \ln K$ $\ln\frac{K_2}{K_1} = \frac{-\Delta H°}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$
Miscellaneous $A = -\log\frac{I}{I_0}$ $A = \varepsilon cl$ $E = -A\frac{e^2}{4\pi\varepsilon_0 r}N_A$	**Colligative Properties & Solutions** $\Pi = cRT$ $P_{solution} = X_{solvent} \times P°_{solvent}$ $c = kp$ $\Delta T_f = K_f m$ $\Delta T_b = K_b m$

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]	112 COPERNICIUM **Cn** [283]						

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]