Topics in the November 2014 Exam Paper for CHEM1612

Click on the links for resources on each topic.

2014-N-2:

- Acids and Bases
- Complexes
- Chemical Equilibrium
- Chemical Kinetics
- Introduction to Chemical Energetics

2014-N-3:

- Introduction to Chemical Energetics
- Acids and Bases

2014-N-4:

- Solutions
- Introduction to Chemical Energetics

2014-N-5:

- Introduction to Chemical Energetics

2014-N-6:

- Introduction to Chemical Energetics

2014-N-7:

- Acids and Bases

2014-N-8:

- Acids and Bases

2014-N-9:

- Chemical Equilibrium

2014-N-10:

- Radiochemistry
- Complexes

2014-N-11:

- Solubility
- Complexes

2014-N-12:

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

2014-N-13:

- Redox Reactions and Introduction to Electrochemistry

2014-N-14:

- Chemical Kinetics

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THE UNIVERSITY OF SYDNEY

SEAT NUMBER: .....

STUDENT ID: .....

SURNAME: .....

GIVEN NAMES: .....

CHEM1612
Chemistry B (Pharmacy)

Final Examination
Semester 2, 2014

Time Allowed: Three hours + 10 minutes reading time

This examination paper consists of 24 pages

INSTRUCTIONS TO CANDIDATES

1. This is a closed book exam.
2. A simple calculator (programmable versions and PDA's not allowed) may be taken into the exam room.

Make	Model

3. The total score for this paper is 100. The possible score per page is shown in the adjacent table.
4. The paper comprises 30 multiple choice questions and 13 pages of short answer questions. ANSWER ALL QUESTIONS.
5. Follow the instructions on page 2 to record your answers to the multiple choice questions. Use a dark lead pencil so that you can erase errors made on the computer sheet.
6. Answer all short answer questions in the spaces provided on this question paper. Credit may not be given where there is insufficient evidence of the working required to obtain the solution.
7. Take care to write legibly. Write your final answers in ink, not pencil.
8. 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.

Page(s)	Marks Max	Marks Gained		Marker
~~2-10~~	~~30~~			~~MCQ~~
11	6			
12	7			
13	4			
14	3			
15	3			
16	7			
17	2			
18	4			
19	8			
20	7			
21	7			
22	8			
23	4			
Total	100			
Check Total				

• Explain the following terms or concepts.	**Marks**
	3
Lewis base	
Le Châtelier's principle	
Heterogeneous catalysis	

• A bar of hot iron with a mass of 1.000 kg and a temperature of 100.00 °C is plunged into an insulated tank of water. The mass of water was 2.000 kg and its initial temperature was 25.00 °C. What will the temperature of the resulting system be when it has reached equilibrium? The specific heat capacities of water and iron are 4.184 J g^{-1} K^{-1} and 0.4498 J g^{-1} K^{-1}, respectively.	**3**
Answer:	

Page Total:

	Marks
• A mass of 1.250 g of benzoic acid, $C_7H_6O_2$, underwent combustion in a bomb calorimeter. The heat of combustion of benzoic acid is –3226 kJ mol^{-1}. What is the change in internal energy during this reaction?	**4**
Answer:	
If the heat capacity of the calorimeter is 10.134 kJ K^{-1}, calculate the temperature change that should have occurred in the apparatus.	
Answer:	
• Phenylketonuria is an inherited disorder in which phenylacetic acid, $C_6H_5CH_2COOH$, (simplified here to HPAc) accumulates in the blood. 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:	

Page Total:

Marks

- The freezing point of a sample of seawater is measured as –2.15 °C at 1 atm pressure. Assuming that the concentrations of other solutes are negligible, determine the molality (in mol kg^{-1}) of NaCl in this sample. The molal freezing point depression constant for H_2O is 1.86 °C kg mol^{-1}. **3**

Answer:

- What is the value of the enthalpy change for the following reaction? **1**

$$MgO(s) + CO_2(g) \rightarrow MgCO_3(s)$$

Data:

Compound	MgO(s)	$CO_2(g)$	$MgCO_3(s)$
$\Delta_f H°$ / kJ mol^{-1}	–602	–394	–1096

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Page Total:

Marks
3

- Consider the following reaction and associated thermochemical data?

$$2NO_2(g) \text{ É } N_2O_4(g)$$

Data:

Compound	$NO_2(g)$	$N_2O_4(g)$
$\Delta_f H°$ / kJ mol^{-1}	33	9
$S°$ / J K^{-1} mol^{-1}	240	304

What is the expression for the equilibrium constant, K_c, for this reaction?

What are the values of $\Delta H°$ and $\Delta S°$ for the reaction?

$\Delta H° =$	$\Delta S° =$

What is the value of $\Delta G°$ for the reaction at 298 K?

$\Delta G° =$

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Page Total:

Marks
3

- Consider the following reaction:

$$2N_2O(g) + 3O_2(g) \rightarrow 4NO_2(g)$$

Calculate $\Delta G°$ for this reaction given the following data.

$4NO(g) \rightarrow 2N_2O(g) + O_2(g)$ $\Delta G° = -139.56$ kJ mol^{-1}

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ $\Delta G° = -69.70$ kJ mol^{-1}

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Page Total:

- A sample of hydrofluoric acid (0.10 M, 25.0 mL) is titrated with 0.10 M NaOH. The pK_a of hydrofluoric acid, HF, is 3.17. Calculate the pH at the following four points.

Marks 7

before any NaOH is added

pH =

when half of the HF has been neutralised

pH =

at the equivalence point

pH =

after the addition of 37.5 mL of NaOH

pH =

THIS QUESTION CONTINUES ON THE NEXT PAGE.

Page Total:

Sketch the titration curve.	**Marks** **2**

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Page Total:

Marks
4

- At 700 °C, hydrogen and iodine react according to the following equation.

$$H_2(g) + I_2(g) \text{ É } 2HI(g) \qquad K_c = 49.0$$

If 0.250 mol of HI(g) is introduced into a 2.00 L flask at 700 °C, what will be the concentration of $I_2(g)$ at equilibrium?

Answer:

Hydrogen also reacts with sulfur at 700 °C:

$$2H_2(g) + S_2(g) \text{ É } 2H_2S(g) \qquad K_c = 1.075 \times 10^8$$

Determine K_c for the following overall equilibrium reaction at 700 °C.

$$2I_2(g) + 2H_2S(g) \text{ É } S_2(g) + 4HI(g)$$

Answer:

Page Total:

Marks

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

Electron capture by ^{37}Ar	
Positron emission by ^{93}Ru	
Beta particle emission by ^{42}K	
Alpha particle emission by ^{251}Cf	

- Give the oxidation number of the indicated atom in the following compounds. **2**

Compound	Atom	Oxidation number
HNO_2	N	
NI_3	N	
$[Co(NH_3)_5Cl]SO_4$	Co	
$K_3[CrCl_6]$	Cr	

- Write down the formulas for the following compounds. **2**

Compound	Formula
hexaaquacobalt(II) carbonate	
tetraamminecopper(II) sulfate	
ammonium hexafluoridoferrate(III)	
potassium hexacyanidomanganate(II)	

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Page Total:

Marks 7

- The K_{sp} of AgBr is 5.0×10^{-13}. The K_{stab} of $[Ag(S_2O_3)_2]^{3-}$ is 4.7×10^{13}. Calculate the value of the equilibrium constant for the dissolution of AgBr in $Na_2S_2O_3$ solution.

Answer:

Calculate the solubility of AgBr in 2.0 M $Na_2S_2O_3$.

Answer:

The K_{stab} for $[Ag(S_2O_3)_2]^{3-}$ is much greater than the K_{stab} for $[Ag(NH_3)_2]^{+}$. Explain why this is so.

Page Total:

	Marks
• Draw sketches of a detergent micelle, a lipid vesicle and a water-in-oil microemulsion.	**3**
• In the electrolytic production of Al, what mass of Al can be deposited in 2.00 hours by a current of 1.8 A?	**2**
Answer:	
• What products would you expect at the anode and the cathode on electrolysis of a 1 M aqueous solution of NiI_2? Explain your answers.	**2**

Page Total:

Marks 8

- An electrochemical cell is consists of 1.0 L half-cells of Fe/Fe^{2+} and Cd/Cd^{2+} with the following initial concentrations: $[Fe^{2+}] = 0.800$ M, $[Cd^{2+}] = 0.200$ M.

  What is the initial E_{cell} at 25 °C?

Answer:

What is E_{cell} when $[Cd^{2+}]$ reaches 0.15 M?

Answer:

What is $[Cd^{2+}]$ when E_{cell} reaches 0.015 V?

Answer:

What are the equilibrium concentrations of both ions?

$[Cd^{2+}] =$ $[Fe^{2+}] =$

Page Total:

Marks 4

- At a certain temperature the following data were collected for the reaction shown.

$$2ICl + H_2 \rightarrow I_2 + 2HCl$$

Experiment	Initial [ICl] (mol L^{-1})	Initial [H_2] (mol L^{-1})	Rate of formation of [I_2] (mol L^{-1} s^{-1})
1	0.10	0.10	0.0015
2	0.20	0.10	0.0030
3	0.10	0.050	0.00075

Determine the rate law for the reaction.

What is the value of the rate constant?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Page Total:

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Page Total:

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
10^{12}	tera	T

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	(+0.82 at pH = 7)
$Pt^{2+}(aq) + 2e^- \rightarrow Pt(s)$	+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	
$I_2(aq) + 2e^- \rightarrow 2I^-(aq)$	+0.62	
$Cu^+(aq) + e^- \rightarrow Cu(s)$	+0.53	
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34	
$BiO^+(aq) + 2H^+(aq) + 3e^- \rightarrow Bi(s) + H_2O$	+0.32	
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	+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	(–0.41 at pH = 7)
$Cr^{2+}(aq) + 2e^- \rightarrow Cr(s)$	–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	

Useful formulas

Thermodynamics & Equilibrium

$\Delta U = q + w = q - p\Delta V$

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta G = \Delta G° + RT \ln Q$

$\Delta G° = -RT \ln K$

$\Delta_{univ} S° = R \ln K$

$$\ln \frac{K_2}{K_1} = \frac{-\Delta H°}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Electrochemistry

$\Delta G° = -nFE°$

Moles of $e^- = It/F$

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

$= E° - (RT/nF) \times \ln Q$

$E° = (RT/nF) \times 2.303 \log K$

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

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

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 $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$\ln x = 2.303 \log x$

Area of circle $= \pi r^2$

Surface area of sphere $= 4\pi r^2$

Volume of sphere $= {}^4/_3 \pi r^3$

Quantum Chemistry

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

$\lambda = h/mv$

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

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

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

$T\lambda = 2.898 \times 10^6$ K nm

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]		114 FLEROVIUM **Fl** [289]		116 LIVERMORIUM **Lv** [293]		

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]

CC01611(b)

CHEM1612

2014, Semester 2