89/07(a)

The University of Sydney

CHEM1612 - CHEMISTRY 1B (PHARMACY)

SECOND SEMESTER EXAMINATION

CONFIDENTIAL

NOVEMBER 2004 **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
2-10	36	

INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 19 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 14, 17, 21 and 24 are for rough working only.

Short answer section

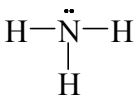
Page	Marks Max	Gained		Marker
11	14			
12	5			
13	5			
15	5			
16	7			
18	7			
19	4			
20	7			
22	4			
23	6			
Total	64			

Marks

- Write the ground state electronic configuration of the Cl^- ion. **5**

How many electrons in this ion have quantum number $l = 1$ (as one of their quantum numbers)?	
How many electrons in this ion have quantum numbers $n = 3$ and $l = 0$?	
How many electrons in the Cl^- ion have quantum numbers $n = 4$, $l = 1$, $m_l = -2$ and $m_s = +½$?	
How many valence electrons in a chlorine atom?	

- Complete the following table. NH_3 is given as an example. **6**

Species	Central atom	Lewis structure	Hybridisation	Geometry of molecule	Polarity of molecule
NH_3	N		sp^3	trigonal pyramidal	polar
PCl_5					
SO_2					

- The three C–O bonds in the carbonate ion, CO_3^{2-}, all have the same bond length, whereas there are two different C–O bond lengths in the hydrogencarbonate ion, HCO_3^-. Explain. **3**

	Marks
• TiO_2 can absorb ultraviolet light. How much energy is gained by TiO_2 when 1.00 mol of photons of ultraviolet light with a wavelength of 350 nm is absorbed?	**2**
Answer:	
• Ethylene glycol antifreeze, $C_2H_6O_2$, (1.00 kg) is added to a car radiator that contains 5.00 kg of water. What is the freezing point of the solution obtained? Data: The molal freezing point depression constant for water $K_f = 1.86$ °C kg mol^{-1}.	**3**

Marks 5

- For the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ at 25 °C

  $\Delta H° = -198.4$ kJ mol^{-1} and $\Delta S° = -187.9$ J K^{-1} mol^{-1}

  Show that this reaction is spontaneous at 25 °C.

If the volume of the reaction system is increased at 25 °C, in which direction will the reaction move?

Calculate the value of the equilibrium constant, K, at 25 °C.

$K =$

Assuming $\Delta H°$ and $\Delta S°$ are independent of temperature, in which temperature range is the reaction non-spontaneous?

Answer:

Marks

- Anhydrous copper(II) sulfate is a white powder that reacts with water to give the familiar light blue crystals of copper(II) sulfate-5-water.

  $$CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4 \cdot 5H_2O(s)$$

  Calculate the standard enthalpy change for this reaction from the heats of solution.

Compound	$\Delta H°_{solution}$ / kJ mol^{-1}
$CuSO_4(s)$	-66.5
$CuSO_4 \cdot 5H_2O(s)$	+11.7

2

Answer:

- Using the given data, calculate $\Delta H°$ for the reaction: $H(g) + Br(g) \rightarrow HBr(g)$

  Data: $H_2(g) \rightarrow 2H(g)$ $\Delta H° = +436$ kJ mol^{-1}

  $Br_2(g) \rightarrow 2Br(g)$ $\Delta H° = +193$ kJ mol^{-1}

  $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$ $\Delta H° = -72$ kJ mol^{-1}

3

Answer:

Marks 7

- Uric acid, $C_5H_5N_4O_3$, is a weak diprotic acid with a low solubility of 70 mg L^{-1}. The extremely painful inflammation known as gout occurs when crystals of uric acid are deposited in the joints. Given that the pH of a saturated solution of uric acid is 4.58, calculate the pK_{a1} of uric acid at 25 °C?

Answer:

The monosodium salt of uric acid is slightly more soluble, 8×10^{-4} g mL^{-1}. Calculate the solubility product constant, K_{sp}, of sodium urate at 25 °C. Assume no hydrolysis of the urate ion occurs.

Answer:

Suggest a possible reason why the pH of blood plasma remains near 7.4 even when saturated with uric acid.

	Marks
• It takes 2.30 minutes to plate out all of the silver from 0.250 L of a solution containing $Ag^+(aq)$, using a current of 2.00 A. What was the original concentration of $Ag^+(aq)$ in solution?	**2**
Answer:	
• A number of bacteria can reduce the nitrate ion in the presence of sulfur. A simplified unbalanced redox reaction can be written as: $S(s) + NO_3^-(aq) \rightarrow SO_2(g) + NO(g)$ Balance this redox equation for acidic conditions.	**3**
• Coordination complexes can display a number of types of isomerism. Draw a simple diagram showing a pair of geometric isomers. Label your diagram with the systematic name of each isomer.	**2**

Marks

- Consider the following balanced redox reaction. **2**

$$2In(s) + 3MnO_2(s) + 12H^+(aq) \rightarrow 2In^{3+}(aq) + 3Mn^{2+}(aq) + 6H_2O$$

If $E^o = 1.568$ V, what would be the measured potential of this cell at 298 K at the following concentrations?

$[H^+(aq)] = 0.25$ M; $[In^{3+}(aq)] = 0.20$ M; $[Mn^{2+}(aq)] = 0.42$ M

Answer:

- What is the value of the equilibrium constant for the following reaction at 298 K? **2**

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

Relevant electrode potentials can be found on the data page.

Answer:

	Marks
• A watch contains a radioactive substance with a decay constant of 1.40×10^{-2} year^{-1}. After 50 years 25 mg of the radioactive material remains. Calculate the amount originally present.	**2**
Answer:	
• Calculate the molar solubility of $PbCl_2$ in water. K_{sp} for $PbCl_2 = 2.0 \times 10^{-5}$ M^3.	**2**
Answer:	
• Complete the following table.	**3**

Formula	Systematic name
$[Cr(OH_2)_5Cl]Cl_2$	
$NH_4Fe(SO_4)_2 \cdot 6H_2O$	
	sodium hexachlorocobaltate(III)
	aluminium nitrate-9-water
	potassium nitrite
$KHSO_4$	

Marks 4

- Consider the results of the following set of experiments studying the rate of the chemical reaction: $2A + B \rightarrow 3C + D$

Experiment #	initial [A] / M	initial [B] / M	Rate / M hr^{-1}
1	0.240	0.120	2.00
2	0.120	0.120	0.500
3	0.240	0.060	1.00

Write the rate law expression.

Rate =

Calculate the rate constant, *k*, with units.

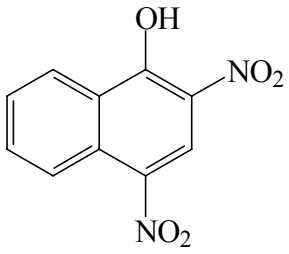
k =

What is the rate of the reaction when [A] is 0.0140 M and [B] is 1.35 M?

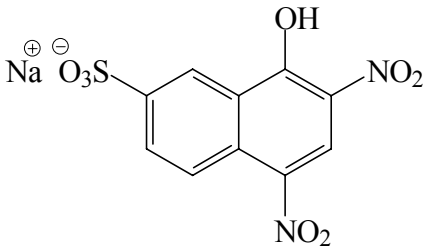
Rate =

Marks

- Consider the following two compounds. **3**



(I) Martius Yellow



(II) Naphthol Yellow S

On ingestion of compound (I), death from liver failure occurs very quickly. In contrast, compound (II) is completely non-toxic and is used as an artificial colouring agent. Explain, using the model of biological membranes, why (I) is highly toxic.

- Give three examples of colloids in biological systems, and complete the following table. Paint is given as an example of a synthetic (non-biological) system. **3**

Name of colloid	Discrete phase	Continuous phase
paint	*synthetic polymer*	*water*

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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}

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

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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
$Cl_2 + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2 + 4H^+(aq) + 4e^- \rightarrow 2H_2O$	+1.23
$Pd^{2+}(aq) + 2e^- \rightarrow Pd(s)$	+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

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Useful Formulas

Quantum Chemistry

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

$\lambda = h/mu$

$4.5k_BT = hc/\lambda$

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

Thermodynamics & Equilibrium

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta G = \Delta G° + RT\ \ln Q$

$\Delta G° = -RT\ \ln K$

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

Kinetics

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

$t_{½} = \ln 2/k$

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

Radioactivity

$A = \lambda N$

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

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

Gas Laws

$PV = nRT$

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

Acids and Bases

$pK_w = pH + pOH\ = 14.00$

$pK_w = pK_a + pK_b\ = 14.00$

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

Colligative Properties

$\pi = cRT$

$p = kc$

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

$\Delta T_f = K_f m$

$\Delta T_b = K_b m$

Electrochemistry

$\Delta G° = -nFE°$

$\text{Moles of } e^- = It/F$

$E = E° - (RT/nF)\ \ln Q$

$= E° - (RT/nF) \times 2.303\ \log Q$

$E° = (RT/nF)\ \ln K$

$= (RT/nF) \times 2.303\ \log K$

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

Polymers

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

Mathematics

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

$\ln x = 2.303\ \log x$

PERIODIC TABLE OF THE ELEMENTS

November 2004

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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]