22/03(a) # The University of Sydney

CHEM1909 - CHEMISTRY 1 LIFE SCIENCES B MOLECULAR (ADVANCED)

SECOND SEMESTER EXAMINATION

CONFIDENTIAL

NOVEMBER 2000

TIME ALLOWED: THREE HOURS

GIVE THE FOLLOWING INFORMATION IN BLOCK LETTERS

SURNAME			**OTHER NAMES**		
SID NUMBER		**FACULTY**		**TABLE NUMBER**	

OFFICIAL USE ONLY

Multiple choice section

	Marks	
Pages	Max	Gained
2-12	50	

Short answer section

Page	Marks: Max	Marks: Gained		Marker
13	8			
15	10			
16	8			
17	8			
18	8			
19	8			
Total	50			
Check Total				

INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 17 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 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.
- Some useful formulas, a Periodic Table and numerical values required for any question may be found on a separate data sheet.
- Pages 14 and 20 are for rough working only.

Marks
8

- Copper(I) oxide may be reduced by carbon according to the equation:

$$Cu_2O(s) + C(s) \rightarrow 2Cu(s) + CO(g)$$

Given the following data, calculate $\Delta H°$, $\Delta S°$ and $\Delta G°$ for the reaction at 298 K.

	$\Delta H°_f$ (298 K) / kJ mol^{-1}	$S°$ (298 K) / J K^{-1} mol^{-1}
$Cu_2O(s)$	-169	93
C(s)	0	6.0
Cu(s)	0	33
CO(g)	-111	198

$\Delta H°$ =

$\Delta S°$ =

$\Delta G°$ =

At what temperature does the reaction become spontaneous?

	Answer:

Marks

- At 25 °C, CO(g) at 1 atm is in equilibrium with a CO(aq) solution at a concentration of 8.50×10^{-4} M. Calculate the equilibrium concentration of CO(aq) when the partial pressure of CO(g) is 0.15 atm. **2**

Answer:

- Consider the following equilibria at 300 K. **4**

$$\tfrac{1}{2}N_2(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons NO(g) \qquad K_c = 4.8 \times 10^{-10}$$

$$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g) \qquad K_c = 1.1 \times 10^{-5}\ \text{M}$$

Determine the value of K_c and K_p at 300 K for the equilibrium:

$$2NO_2(g) \rightleftharpoons N_2(g) + 2O_2(g)$$

K_c =	K_p =

- Lactic acid, $CH_3CH(OH)COOH$, accumulates in the muscles during exercise. It is a monoprotic acid with ionisation constant $K_a = 1.4 \times 10^{-4}$ M. What is the pH of a 0.050 M lactic acid solution? **4**

	pH =

Marks
8

- The $H_2PO_4^-$ and HPO_4^{2-} ions play a role in maintaining the pH of blood. Write equations to show how a solution containing these ions functions as a buffer.

The K_{a2} for phosphoric acid is 6.3×10^{-8} M. At what pH is the $H_2PO_4^-$ / HPO_4^{2-} buffer system most effective?

pH =

Calculate the ratio of $[H_2PO_4^-]$ / $[HPO_4^{2-}]$ required to give a buffer with a pH of 7.68.

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks

- EDTA is a ligand that forms complexes with many metals and may be used to treat heavy metal toxicity in the body. The reaction with lead ions is represented by the following equilibrium. 4

$$Pb^{2+}(aq) + EDTA^{4-}(aq) \rightleftharpoons [PbEDTA]^{2-}(aq) \qquad K_{stab} = 1 \times 10^{18}\ M^{-1}$$

If a solution has an initial concentration of Pb^{2+}(aq) of 0.001 M and $EDTA^{4-}$ (aq) of 0.050 M, what is the concentration of uncomplexed lead ions once equilibrium has been established?

Answer:

- Calculate the mass of copper that deposits when a current of 1.5 A is passed for 10 minutes through a solution containing Cu^{2+} ions. 2

Answer:

- Briefly describe the structure of a micelle. 2

Marks

- One of the key reactions in the formation of acid rain and in the industrial production of nitric acid is the reaction of nitric oxide with oxygen: **4**

$$O_2(g) + 2NO(g) \rightarrow 2NO_2(g)$$

The following data were obtained at constant temperature.

EXPERIMENT NUMBER	INITIAL CONCENTRATIONS (mol L^{-1}) $[O_2]$	$[NO]$	INITIAL REACTION RATE (mol L^{-1} s^{-1})
1	1.10×10^{-2}	1.30×10^{-2}	3.21×10^{-3}
2	2.20×10^{-2}	1.30×10^{-2}	6.40×10^{-3}
3	1.10×10^{-2}	2.60×10^{-2}	12.8×10^{-3}
4	3.30×10^{-2}	1.30×10^{-2}	9.60×10^{-3}

Deduce the rate equation for this reaction and find the value of the rate constant.

Rate equation	Rate constant
Answer:	Answer:

- The reaction $2NO_2(g) + F_2(g) \rightarrow 2NO_2F(g)$ is postulated to occur in two steps, the first of which is the rate determining step **2**

$NO_2(g) + F_2(g) \rightarrow NO_2F(g) + F(g)$ STEP 1

$NO_2(g) + F(g) \rightarrow NO_2F(g)$ STEP 2

Deduce the expected rate expression for this mechanism.

- Sketch an energy diagram to represent a reaction in which ΔH = -40 kJ mol^{-1} and E_a = 40 kJ mol^{-1}. **2**

Marks

- Identify the element to which each of the following statements refers. **4**

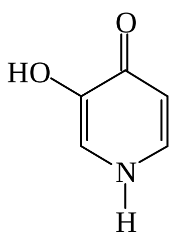
Important metal in Vitamin B_{12}.

Dietary deficiency causes goitre.

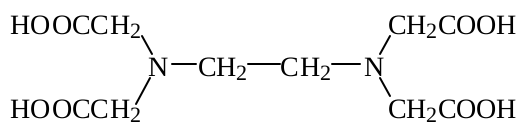
Used in the treatment of manic depression patients.

Retained in the body in Menke's syndrome and in Wilson's disease.

- Thalassemia, a genetic blood disorder, results in the toxic accumulation of iron in the body. It might be treated by administration of EDTA (ethylenediaminetetraacetic acid) or 3-hydroxypyridin-4-one. **4**



3-hydroxypyridin-4-one



EDTA

Briefly describe the chemical basis for the use of these agents in the treatment of thalassemia.

Giving your reasons, state which of EDTA and 3-hydroxypyridin-4-one would be the agent of choice in this treatment, based on the data in the following table which gives the logarithms of complex formation constants between selected metals and EDTA and 3-hydroxypyridin-4-one.

Ion	EDTA	3-hydroxypyridin-4-one
Fe(III)	25	37
Cu(II)	18	17
Zn(II)	16	12.5

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Faraday constant = F = 96485 coulomb mole^{-1}

Avogadro constant = N_A = 6.022×10^{23} mole^{-1}

Standard atmosphere = 101 325 pascal = 760 mmHg

Ideal gas constant = R = 8.314 joule kelvin^{-1} mole^{-1}

= 0.08206 litre atmosphere kelvin^{-1} mole^{-1}

Conversion factors

0 degree Celsius = 273 kelvin

1 kJ = 1 kilojoule = 10^3 joule

1 L = 1 litre = 10^{-3} metre^3

1 mL = 1 millilitre = 10^{-3} litre

1 mA = 1 milliampere = 10^{-3} ampere

Standard Reduction Potentials at 298 K

$$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) \quad E° = +0.34$$

$$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s) \quad E° = -0.24$$

$$2H^+(aq) + 2e^- \rightleftharpoons H_2(g) \quad E° = 0.00$$

$$\tfrac{1}{2}O_2(g) + 2H^+(aq) + 2e^- \rightleftharpoons H_2O \quad E° = +1.23$$

Useful Formulas

Thermodynamics and Equilibrium

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta G° = -RT \ln K$

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

Solution properties

$\pi = cRT$

$p = kc$

Acids and Bases

pK_w = pH + pOH = 14

$pK_w = pK_a + pK_b = 14$

pH = pK_a + log{ [base] / [acid] }

Kinetics

$t_{½} = \ln 2/k$

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

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

Electrochemistry

$\Delta G° = -nFE°$

$E = E° - RT/nF \ln Q$

$E° = RT/nF \ln K$

Moles of e^- = It/F

A periodic table is printed on the other side of this data sheet.

Atomic weights are included in the periodic table....

November

CHEM1909

22/03(b)
2000

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]									

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]