22/03(a) # The University of Sydney

CHEM1909 - CHEMISTRY 1 LIFE SCIENCES B MOLECULAR (ADVANCED)

SECOND SEMESTER EXAMINATION

CONFIDENTIAL

NOVEMBER 2002 **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
2-8	28	

INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 16 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.
- Some useful formulas, a Periodic Table and numerical values required for any question may be found on a separate data sheet.
- Pages 11, 14 and 20 are for rough working only.

Short answer section

Page	Marks Max	Marks Gained		Marker
9	9			
10	10			
12	8			
13	13			
15	7			
16	9			
17	6			
18	4			
19	6			
Total	72			

Marks 9

- Write a balanced equation for the oxidation of glucose ($C_6H_{12}O_6$) to carbon dioxide and water.

Given the following, 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}
$C_6H_{12}O_6(s)$	–1274	212
$O_2(g)$	0	205
$CO_2(g)$	–393	214
$H_2O(l)$	–286	69.9

$\Delta H°$ =

$\Delta S°$ =

$\Delta G°$ =

A typical oxygen consumption for a 70 kg person at rest is 8.60×10^{-3} mol minute^{-1} at 298 K and 1 atm. Suppose this amount of oxygen gas is all used in the oxidation of glucose. Calculate the enthalpy production (in kJ min^{-1}) of this person at rest.

$\Delta H°$ =

Marks

- Consider the reaction: $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

  Determine the equilibrium constant (K_{p1}) for this reaction at 25 °C. **6**

  Data: $2H_2O(g) \rightleftharpoons 2H_2(g) + O_2(g)$ $\quad K_{p2} = 1.6 \times 10^{-11}$ atm at 25 °C

  $2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g)$ $\quad K_{p3} = 1.3 \times 10^{-10}$ atm at 25 °C

K_{p1} =

Calculate $\Delta G°$ for this reaction at 25 °C.

$\Delta G°$ =

- Trichloroacetic acid (CCl_3COOH) is a corrosive acid used to precipitate proteins. The pH of a 0.050 M solution is 1.40. Calculate K_a. **4**

K_a =

	Marks
• The pyridinium ion is a weak monoprotic acid with a pK_a of 5.22. A 25.0 mL sample of a 0.100 M pyridinium chloride solution was titrated with 0.0500 M NaOH. Calculate the pH of the solution after addition of the following amounts of sodium hydroxide solution: 0.00 mL, 30.0 mL, 50.0 mL, 75.0 mL.	**8**

0.0 mL	
	pH =
30.0 mL	
	pH =
50.0 mL	
	pH =
75.0 mL	
	pH =

- Draw the Lewis structures (including resonance structures where appropriate) of chlorine pentafluoride, formate ion and allene. Indicate the hybridisation of the underlined atom and shape of the molecule or ion.

Marks 9

Species	Lewis structure	Hybridisation of underlined atom	Shape of molecule or ion
$\underline{Cl}F_5$			
$H\underline{C}O_2^-$			
$H_2C\underline{C}CH_2$			

- When heated, lithium atoms emit photons of red light with a wavelength of 670 nm. What is the energy (in kJ mol^{-1}) and frequency of this radiation?

4

E =	ν =

- Calculate the molar solubility of limestone, $CaCO_3$, given $K_{sp} = 3.3 \times 10^{-9}\ M^{-2}$.

Marks **4**

Answer:

With the aid of equations, explain the effect acid rain would have on the solubility of limestone.

- At what temperature would a solution of iodine (0.645 g) in cyclohexane (50.0 g) freeze? The normal melting point of cyclohexane is 6.6 °C and $K_f = 20.0$ K kg mol^{-1}.

3

Answer:

- How long must a current of 2.0 A be applied to a pure $AgNO_3$ solution to deposit 1.0 g of silver?

Marks **3**

Answer:

- Typical concentrations of Na^+ and K^+ in the intracellular and extracellular fluid are given below.

  Na^+ = 142 mM extracellular, 10 mM intracellular

  K^+ = 4 mM extracellular, 140 mM intracellular

  Estimate the potential difference between the inside and outside of a cell at 37 °C.

3

Answer:

- Use the standard reduction potentials on the data page to calculate the value of $\Delta G°$ (Gibbs free energy of reaction) for the following reaction.

$$2H^+(aq) + H_2O_2(aq) + 2Fe^{2+}(aq) \rightarrow 2Fe^{3+}(aq) + 2H_2O$$

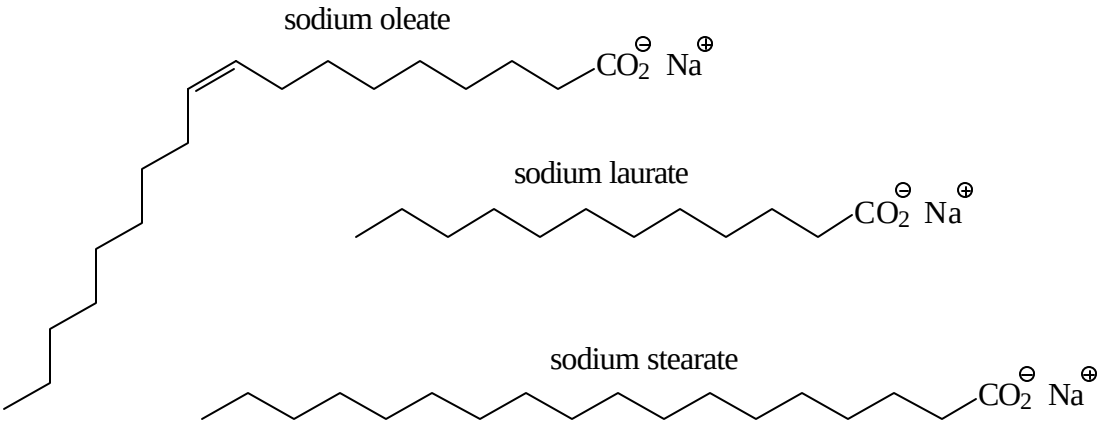
3

Answer:

Marks

- Which of the surfactants below would have the lowest critical micelle concentration (CMC)? Which one would have the highest? Why?

4



- What is enzyme catalysis? List the distinctive features, advantages and disadvantages of enzyme catalysis for carrying out chemical syntheses?

2

	Marks
• The rate constant for the unimolecular cyclisation of compound X triples when the temperature is increased from 25 °C to 45 °C. Calculate the activation energy, E_a, for this reaction.	**4**

E_a =

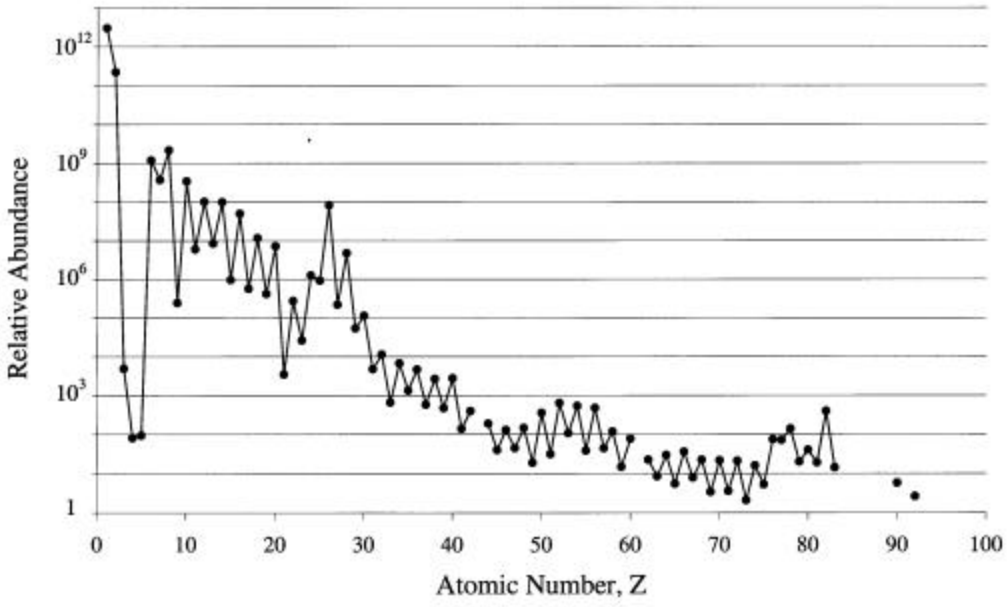
If the initial rate of cyclisation measured in a 1.0 M solution of compound X is 1.4 mM s^{-1} at 25 °C, what is the half life of compound X at 25 °C?

$t_{½}$ =

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

- The figure below shows the estimated abundance of each element in the Universe on a log scale.

Marks
3



Explain the main features of this curve.

- Consider the following three isotopes of neon: ^{19}Ne, ^{20}Ne and ^{23}Ne. Which one of these isotopes is stable? Write balanced equations for the nuclear decay undergone by each of the unstable nuclides.

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Physical constants

Faraday constant = F = 96485 C mol^{-1} Speed of light = $c = 2.998 \times 10^8$ m s^{-1}

Planck constant = $h = 6.626 \times 10^{-34}$ J s Avogadro constant = $N_A = 6.022 \times 10^{23}$ mol^{-1}

Standard atmosphere = 101 325 Pa = 760 mmHg Ideal gas constant R = 8.314 J K^{-1} mol^{-1} = 0.08206 L atm K^{-1} mol^{-1}

Conversion factors

0 °C = 273 K	1 mL = 10^{-3} L	1 L = 10^{-3} m^3	1 mPa = 10^{-3} Pa
1 kJ = 10^3 J	1 mA = 10^{-3} A	1 nm = 10^{-9} m	1 mg = 10^{-3} g

Standard Reduction Potentials at 298 K

$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O$	$E° = +1.78$ V
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	$E° = +0.77$ V
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	$E° = +0.34$ V
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	$E° = 0.00$ V
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	$E° = -0.24$ V
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	$E° = -0.44$ V

Useful Formulas

Thermodynamics and Equilibrium

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta G° = -RT \ln K$

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

Colligative properties

$\pi = cRT$

$p = kc$

$\Delta T_f = K_f m$

Acids and Bases

$pK_w = pH + pOH = 14$

$pK_w = pK_a + pK_b = 14$

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

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 $e^- = It/F$

Quantum Chemistry

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

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

Atomic weights are included in the periodic table.

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]