22/09(a)

The University of Sydney

CHEM1907 - CHEMISTRY 1 LIFE SCIENCES A MOLECULAR (ADVANCED)

CHEM1908 - CHEMISTRY 1 LIFE SCIENCES A (ADVANCED)

FIRST SEMESTER EXAMINATION

CONFIDENTIAL

JUNE 2003

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 14 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 •.
- 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. Logarithms may also be used.
- Numerical values required for any question as well as a Periodic Table are printed on a separate data sheet.
- Page 16 is for rough work only.

OFFICIAL USE ONLY

Multiple choice section

	Marks	
Pages	Max	Gained
6-11	32	

Short answer section

Page	Marks Max	Gained		Marker
2	10			
3	5			
4	10			
5	8			
12	13			
13	8			
14	5			
15	9			
Total	68			

Marks

- Complete the following table. Give, as required, the formula, the systematic name and the principal ions present in a solution prepared by adding the substance to water. For the substances that do not form ions in solution, write N/A in this column. **5**

FORMULA	SYSTEMATIC NAME	PRINCIPAL IONS IN WATER SOLUTION
$MgCl_2$		
	sodium chromate	
CO		
		$H^+(aq)$, $IO^-(aq)$
	iron(III) nitrate-6-water	

- Electron configurations are governed by three rules: the 'Aufbau Principle', the 'Pauli Exclusion Principle' and 'Hund's Rule of Maximum Spin Multiplicity'. The ground state electron configurations of He, N and O have been written INCORRECTLY, as shown below. For each element, name the electron configuration rule that has been broken. **5**

Element	Electron Configuration					Name of rule that has been broken
	1*s*	2*s*	2*p*			
He		↑↓				
N	↑↓	↑↓	↑↓	↑		
O	↑↓	↑↓	↑↑	↑	↑	

Write the electron configuration of Fe^{2+}.

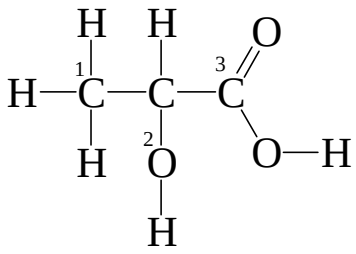
What property of iron makes it useful to biological systems?

• Draw the Lewis structures, showing all valence electrons for the following species. Indicate which of the molecules possess a dipole.		**Marks 5**
CH_3Cl	NO_2F	NCO^-
Dipole: YES / NO	Dipole: YES / NO	

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks 10

- The partial Lewis structure of lactic acid, the molecule that forms in muscle during exercise, is shown below. Complete the Lewis structure of lactic acid by drawing the non-bonded electron pairs around the relevant atoms.



Complete the following table.

Atom	Geometric arrangement of the groups around the atom	Hybridisation of atom
^{1}C		
^{2}O		
^{3}C		

Name three types of intermolecular interactions expected of lactic acid.

The pK_a of lactic acid is 3.08 and the pK_b of ammonia is 4.76. Determine whether products or reactants are favoured in the following equilibrium reaction. Provide a brief rationale for your answer.

$$CH_3CH(OH)COOH + NH_3 \rightleftharpoons CH_3CH(OH)CO_2^- + NH_4^+$$

Marks 8

- One of the causes of acid rain is a reaction occurring in the upper atmosphere between gaseous NO_2 and water to produce nitric acid and gaseous NO. Write a balanced chemical equation for this reaction.

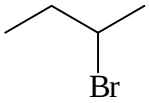
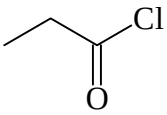
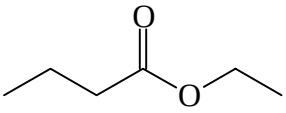
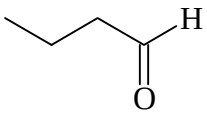
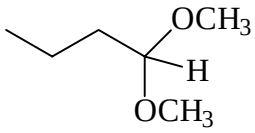
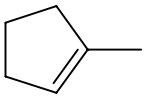
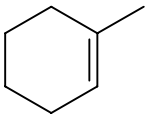
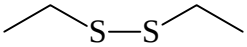
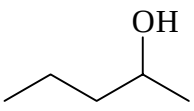
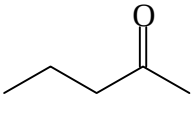
As part of their school project on acid rain, some high school students collected a sample of rain (220 mL) and measured the pH value of the solution, reporting the value as pH = 3.9. Assuming that the rain sample does not contain any acids other than nitric acid, calculate the volume of gaseous NO_2 that would have been consumed in the upper atmosphere (where temperature = –56 °C and pressure = 11.6 kPa) to produce the sample of rain collected by the students.

ANSWER:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

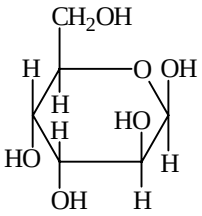
Marks 13

- Complete the following table.

STARTING MATERIAL NAME (where required)	REAGENTS/ CONDITIONS	CONSTITUTIONAL FORMULA(S) OF MAJOR ORGANIC PRODUCT(S)
 Name:	$CH_3CH_2S^{\ominus}\ Na^{\oplus}$	
	excess $(CH_3)_2NH$	
 Name:	3 M HCl / heat	
		
 Name:	H_2 / Pd on C ethanol solvent	
	dilute H_2SO_4 heat	
	Zn / dilute HCl	
		

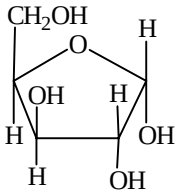
Marks 8

- Consider the following two monosaccharides, (**A**) and (**B**).



(**A**)

β-D-altropyranose



(**B**)

α-D-xylofuranose

Draw Fischer projections of the open chain forms of **A** and **B**.

A	**B**

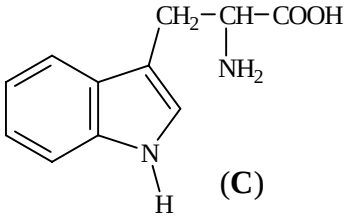
Give the products obtained when D-xylose is treated with the following reagents.

$[Ag(NH_3)_2]^+$ / OH^- solution	$NaBH_4$ in methanol solvent

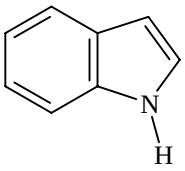
Draw the Haworth structure of a non-reducing disaccharide, which yields D-altrose and D-xylose on acid hydrolysis.

Marks

- The side-chain of the amino acid tryptophan (**C**) is a substituted derivative of the heterocycle indole (**D**). Explain with the aid of diagrams whether you would expect indole to have aromatic stability or not. Would you expect the nitrogen atom of indole to be basic? Give reasons for your answer. **3**

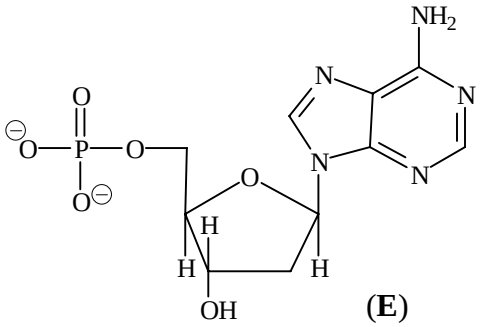


(**C**)



(**D**)

- Hydrolysis of dAMP (**E**), a nucleotide important in DNA synthesis, gives the sugar D-2-deoxyribose and the nucleic base adenine. Give the structure of adenine and the structure of one tautomer of adenine. **2**



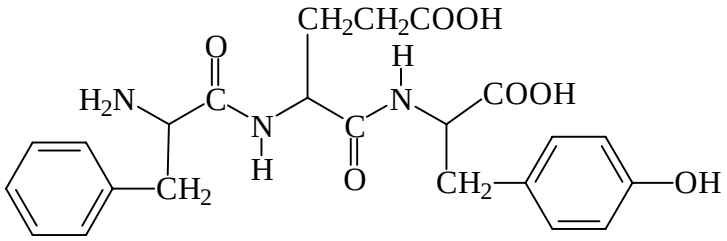
(**E**)

adenine	tautomer of adenine

Marks 9

- Consider the tripeptide phenylalanylglutamyltyrosine (Phe-Glu-Tyr) (**F**), whose constitutional formula is shown below.

(**F**)



Draw the constitutional formula(s) of the product(s) obtained when the tripeptide is subjected to the following conditions.

cold 2 M NaOH

5 M HCl / heat

The pK_a values of tyrosine are pK_{a1} = 2.20 (α-COOH), pK_{a2} = 9.11 (α-$NH_3^{\oplus}$) and pK_{a3} = 10.07 (-$CH_2C_6H_4OH$). Draw the structure of the zwitterionic form of tyrosine.

At what pH will this be the predominant species in aqueous solution?

Give the constitutional formulas for the following dipeptides present in water solution at the indicated pH values.

Tyr-Phe, pH 12.0	Glu-Tyr, pH 1.0

22/09(b)

The University of Sydney

CHEM1907 - CHEMISTRY 1 LIFE SCIENCES A MOLECULAR (ADVANCED)

CHEM1908 - CHEMISTRY 1 LIFE SCIENCES A (ADVANCED)

FIRST SEMESTER EXAMINATION **JUNE 2003**

Numerical Data

Physical constants

Planck constant = $h = 6.626 \times 10^{-34}$ J s

Speed of light in vacuum = $c_o = 2.998 \times 10^{8}$ m s^{-1}

Avogadro constant = $N_A = 6.022 \times 10^{23}$ mol^{-1}

Faraday constant = $F = 96485$ C mol^{-1}

Ideal gas constant $= R = 8.314$ J K^{-1} mol^{-1}

$= 0.08206$ L atm K^{-1} mol^{-1}

Volume of 1 mol of ideal gas at 1 atm, 0 °C = 22.4 L

Volume of 1 mol of ideal gas at 1 atm, 25 °C = 24.5 L

Conversion factors

0 °C = 273 K

1 atm = 101.3 kPa = 760.0 mmHg

1 nm = 10^{-9} m

1 MHz = 10^{6} Hz = 10^{6} s^{-1}

1 L = 10^{-3} m^3

A periodic table is printed on the other side of this data sheet.
Atomic weights are included in the periodic table.

June 2003

CHEM1907/CHEM1908

22/09(b)

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]