22/09(a) The University of Sydney

CHEM1907 - Chemistry 1 Life Sciences A Molecular (Advanced)
and
CHEM1908 - Chemistry 1 Life Sciences A (Advanced)

FIRST SEMESTER EXAMINATION

CONFIDENTIAL

JUNE 2002 **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.
- Page16 is for rough work only.

OFFICIAL USE ONLY

Multiple choice section

	Marks	
Pages	Max	Gained
6–11	32	

Short answer section

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

- 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.

Marks 5

FORMULA	SYSTEMATIC NAME	PRINCIPAL IONS IN WATER SOLUTION
	barium hydroxide	
HBrO		
	potassium nitrite	
		$NH_4^+(aq)$, $SO_4^{2-}(aq)$
$CuCl_2 \cdot 2H_2O$		

- Name the ion with a 2+ charge which has completely filled shells for n = 1, 2 and 3, but no other electrons in shells with $n > 3$.

2

- Sodium chloride is insoluble in diethyl ether ($CH_3CH_2–O–CH_2CH_3$), but soluble in water. Explain this solubility behaviour in terms of intermolecular forces.

3

Marks 10

- Several types of bacteria perform a reaction between urea, $(NH_2)_2CO$, and water to produce ammonia and carbon dioxide. Write a balanced chemical equation for this reaction.

If a colony of bacteria converted 0.057 g of urea to ammonia and carbon dioxide, what volume of carbon dioxide would be produced at 1.0 atm and 37 °C?

ANSWER:

To accelerate the rate of the reaction, the bacteria produce a nickel-containing protein called urease. One molecule of urease contains two nickel ions. Given that the nickel content of urease is 0.14% (i.e. 0.14 g Ni per 100 g enzyme), calculate the molecular weight of urease.

ANSWER:

The nickel in urease is present as Ni^{2+}. Write the ground state electron configuration of Ni^{2+}.

Marks 8

- For each of the following species:

  a) Draw a Lewis structure showing the arrangement of valence shell electron pairs (σ and, where appropriate, π and non-bonding).

  b) Describe the geometry adopted by the electron pairs (σ and non-bonding) as predicted by the valence shell electron pair repulsion (VSEPR) theory.

  c) Describe the shape of the species in words.

  d) Indicate the hybridisation state of the central atom in each of the species.

	CH_2Cl_2	O_3
a)		
b)		
c)		
d)		

	HCN	NO_3^-
a)		
b)		
c)		
d)		

- Gastric juices in the stomach of a healthy human have pH = 2 due to a solution of hydrochloric acid. What is the concentration of hydrochloric acid in healthy human gastric juices, expressed in g L^{-1}?

Marks 5

ANSWER:

An increase in the acidity of the human gastric juices to pH = 1.0 can cause discomfort, known as heartburn. Heartburn can be treated with an antacid preparation, such as Alka-Seltzer ($NaHCO_3$), which neutralises the stomach acid, according to the following equation.

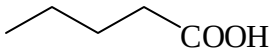
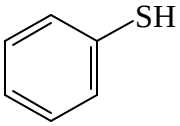
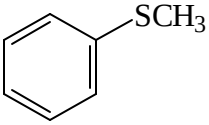
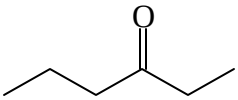
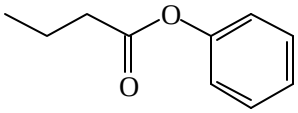
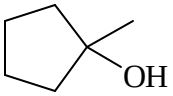
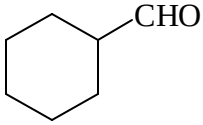
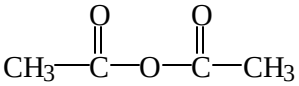
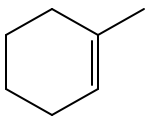
$$H^+(aq) + HCO_3^-(aq) \rightarrow H_2O(l) + CO_2(g)$$

If one tablet of Alka-Seltzer contains 0.50 g of $NaHCO_3$ and the volume of gastric juices is 265 mL, how many tablets of Alka-Seltzer would be required to alter the pH value of the stomach from pH = 1.0 (heartburn) to pH = 2.0 (healthy)?

ANSWER:

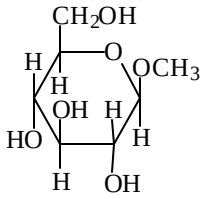
- Complete the following table.

Marks 12

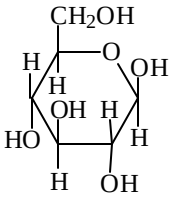
STARTING MATERIAL NAME (where required)	REAGENTS/ CONDITIONS	CONSTITUTIONAL FORMULA(S) OF MAJOR ORGANIC PRODUCT(S)
 Name:	1. $SOCl_2$ / heat 2. CH_3OH	
		
 Name:	1. $NaBH_4$ 2. $H^{\oplus}$ / H_2O	
	$OH^{\ominus}$ / H_2O / heat	
	hot conc. H_2SO_4	
	excess CH_3CH_2OH HCl (catalyst)	
	$CH_3CH_2S^{\ominus}$ $Na^{\oplus}$	
	HBr (CCl_4 solvent)	

Marks 10

- Consider the following two monosaccharides, (**L**) and (**M**).



(**M**)



methyl β-D-glucopyranoside

β-D-glucopyranose

Describe a chemical test that could be used to distinguish (**L**) from (**M**). Include in your answer, the reagent you would use, what would be observed and a chemical equation that explains what is occurring in the reaction.

Give the reagents to convert (**L**) to (**M**).

Give the reagents to convert (**M**) to (**L**).

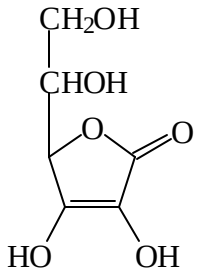
Sugar (**M**) exists in equilibrium with an open chain form. Give the Fischer projection of this open chain form.

List the functional groups present in (**L**).

Draw the Haworth structure of the disaccharide 4-*O*-(β-D-glucopyranosyl)--α-D-glucopyranose.

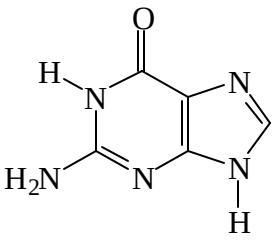
- Ascorbic acid (vitamin C) and guanine, whose structures are shown below, are important biological compounds. Give the constitutional formula of one tautomer of each of these compounds.

Marks 4



ascorbic acid

tautomer of ascorbic acid



guanine

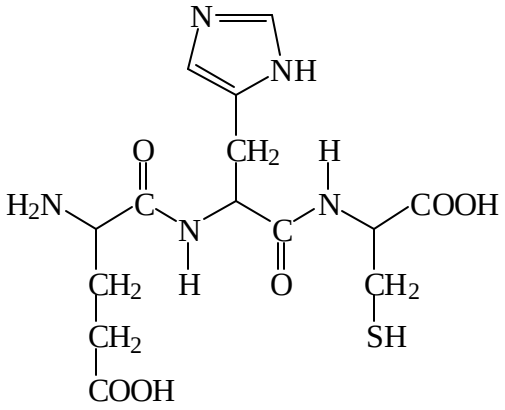
tautomer of guanine

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks 9

- Consider the tripeptide glutamylhistidylcysteine (Glu-His-Cys) (**M**), whose constitutional formula is shown below.

(**M**)



Draw the Fischer projections with L configurations for the amino acids obtained from the hydrolysis of (**M**) using hot concentrated NaOH solution.

The pK_a values of cysteine are pK_{a1} = 1.71 (α-COOH), pK_{a2} = 8.33 (α-$NH_3^{\oplus}$) and pK_{a3} = 10.78 (CH_2SH). Give the structures of the predominant species present in water solutions of cysteine at pH 1.00 and pH 5.02.

pH 1.00	pH 5.02

Give the zwitterionic form of His-Glu.

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Numerical Data

Physical constants

Gas constant = R = 8.314 J K^{-1} mol^{-1}

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

Conversion factors

1 nm = 10^{-9} m

1 kJ = 10^{3} J

1 mg = 10^{-3} g

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

1 mL = 10^{-3} L

1 atm = 101.3 kPa

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

.../2

June 2002

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]