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 2001   **TIME ALLOWED: THREE HOURS**

GIVE THE FOLLOWING INFORMATION IN BLOCK LETTERS

FAMILY NAME		SID NUMBER	
OTHER NAMES		TABLE NUMBER	

INSTRUCTIONS TO CANDIDATES   **OFFICIAL USE ONLY**

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 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.

Pages 5, 17 & 20 are for rough work only.

Multiple choice section

Pages	Max	Gained
		Marks
8-12	25	

Short answer section

Page	Max	Gained		Marker
		Marks		
2	8			
3	7			
4	7			
6	4			
7	6			
13	6			
14	8			
15	7			
16	7			
18	10			
19	5			
Total	75			

- Complete the following table. Give, as required, the systematic name of each substance listed and the formulas of the principal ions present in a solution prepared by adding the substance to water.

Marks 5

FORMULA	SYSTEMATIC NAME	PRINCIPAL IONS IN WATER SOLUTION
		Na^+(aq), OH^-(aq)
$FeCl_3 \cdot 6H_2O$		
	perchloric acid	
	sodium chromate	
CH_3COOH		

- Write the ground state electron configuration of aluminium in terms of subshells.

3

Consider the electron in the orbital of highest energy.

What is the value of the principal quantum number, n?

What is the value of the orbital shape (angular momentum) quantum number, l?

Write all the values that are possible for the orbital orientation (magnetic) quantum number, m_l.

What is the value of the spin quantum number, m_s? (Specify only a single value.)

	Mark s
	4

- Sulfite oxidase, an enzyme present in humans, oxidises sulfite to sulfate, as shown in the equation below. The enzyme contains two molybdenum atoms per molecule of enzyme.

$$SO_3^{2-}(aq) + H_2O \rightleftharpoons SO_4^{2-}(aq) + 2H^+(aq) + 2e^-$$

What is the oxidation number of S in sulfite?

What is the oxidation number of S in sulfate?

A sample of sulfite oxidase was purified and found on analysis to contain 0.188% molybdenum by weight (*ie*. 0.188 g of molybdenum per 100 g of enzyme). What is the molecular weight of the enzyme?

ANSWER:

3

- What is the pH of a 0.0063 M solution of HCl?

ANSWER:

A 5.0 mL aliquot of 0.0063 M HCl solution was transferred to a clean flask, which was then filled with water to a volume of 250 mL. Calculate the pH of the resulting solution.

ANSWER:

- For each of the following ions:

  a) Draw a Lewis structure showing the arrangement of valence shell electron pairs (σ and, where appropriate π and non-bonding). Your structure MUST indicate the correct geometry of the ion as predicted by valence shell electron pair repulsion (VSEPR) theory.

  b) Describe the shape of the ion in words.

  c) Indicate the hybridisation state of the central atom in each of the ions.

Ion	Diagram	Shape of ion	Hybridisation of central atom
NO_2^-			
H_3O^+			
N_3^-			
HCO_2^-			

Which of the above ions display resonance?

	Marks
• Humans contain an average of 5.04 L of blood. If the concentration of glucose ($C_6H_{12}O_6$) in blood is 0.00500 M, what mass of glucose is present in the average human's blood?	**4**

ANSWER:

Glucose is produced by plants during photosynthesis, a process that can be represented by the equation below.

$$6CO_2(g) \ + \ 6H_2O(l) \ \rightleftharpoons \ C_6H_{12}O_6(s) \ + \ 6O_2(g)$$
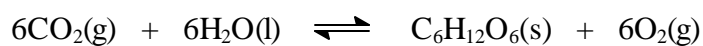
If 0.293 g of glucose is produced by a plant during photosynthesis at 25 °C and 1 atm pressure, what is the mass of oxygen that would be produced under the same conditions?

ANSWER:

The oxygen produced above was transferred to an evacuated vessel with a volume of 245 mL and the vessel was heated to 33 °C. What would be the pressure of the gas in the vessel?

ANSWER:

	Mark s
• The pK_a of HCN is 9.21 and the pK_a of HPO_4^{2-} is 12.38. For the reaction below, indicate on which side the equilibrium will lie. Justify your answer.	2

$$CN^- \ + \ HPO_4^{2-} \ \rightleftharpoons \ HCN \ + \ PO_4^{3-}$$
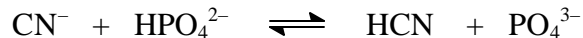
ANSWER:

• **COMPLETE ONLY ONE QUESTION FROM THE FOLLOWING TWO.**

4

Option 1   Metallothionein is a metal-containing protein that regulates the concentration of zinc in cells.

(i)   What atom is most often bound to zinc in metallothionein?
      S, O, Se or H.

(ii) Write the electron configuration of Zn^{2+}.

(iii) Briefly explain what is meant by the term 'redox-active'.

(iv) Give one example of a redox-active metal that has a role in biology.

Option 2   Transferrin is a protein that is involved in the transport on iron in blood.

(i)   What polyatomic ion is bound to iron in transferrin?
      cyanide, sulfite, sulfate or carbonate.

(ii) Write the electron configuration of Fe^{3+}.

(iii) Briefly explain what is meant by the term 'redox-active'.

(iv) Give one example of a redox-inactive metal that has a role in biology.

	Marks
• A structural formula for Warfarin, an anticoagulant, showing all atoms and bonds is shown below. Draw a stick representation of the formula in the adjacent box.	**1**
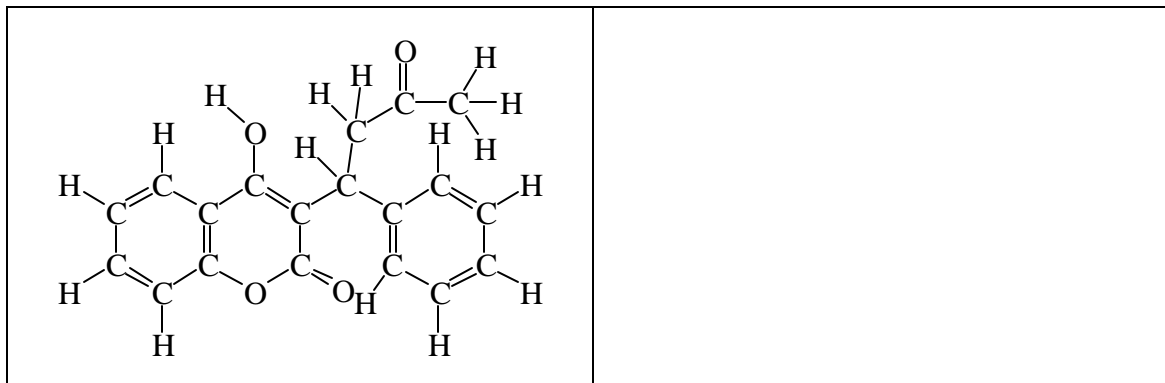
• When 1-methylcyclopentene is treated with hydrogen bromide in water, two carbocations can be formed. Give the structures of these carbocations in the spaces below, indicating which is the more stable species.

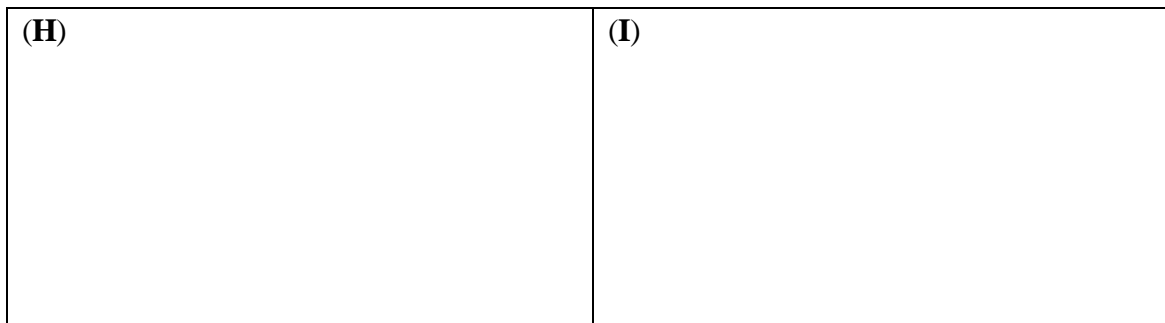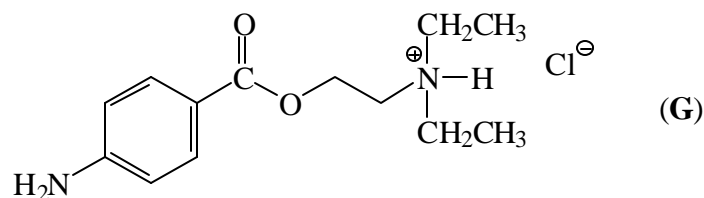**3**

HBr / H$_2$O

More stable carbocation	Less stable carbocation
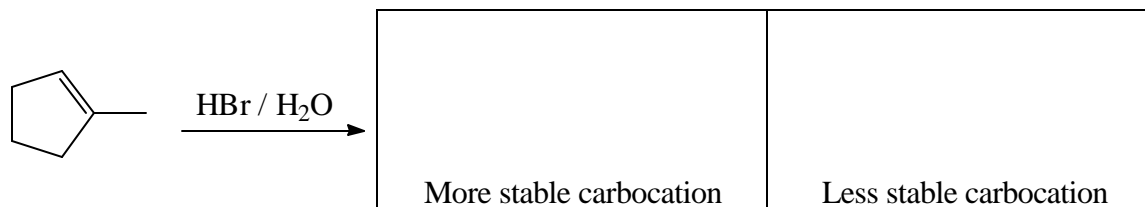
Give the constitutional formulas of the products arising from the more stable carbocation in the above reaction.
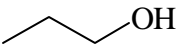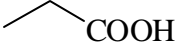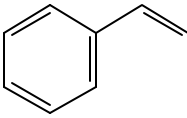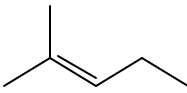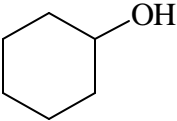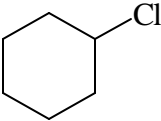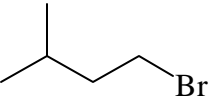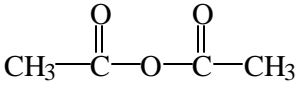
• When the anaesthetic procaine (**G**) is heated with 4 M aqueous NaOH, two products, (**H**) and (**I**) are obtained. Give the constitutional formulas of (**H**) and (**I**).

2

(**G**)

(**H**)	(**I**)

Marks

8

- Complete the following table.

STARTING MATERIAL	REAGENTS/CONDITIONS	CONSTITUTIONAL FORMULA(S) OF MAJOR ORGANIC PRODUCT(S)
CH₃CH₂CH₂OH (propan-1-ol)		CH₃CH₂COOH
styrene (vinylbenzene)	Br₂ / CCl₄ (solvent)	
2-methyl-2-pentene	H₂ / Pd on C ethanol (solvent)	
cyclohexanol (OH)		cyclohexyl chloride (Cl)
1-bromo-3-methylbutane (Br)	NaOCH₃ in methanol (solvent)	
CH₃—C(=O)—O—C(=O)—CH₃ (acetic anhydride)	excess CH₃NH₂ / heat	
acetone (propan-2-one)	excess CH₃CH₂OH HCl (catalyst)	

Marks

7

- The structure of estrone (**A**), an important female hormone, is shown on the right.

(**A**)

HO
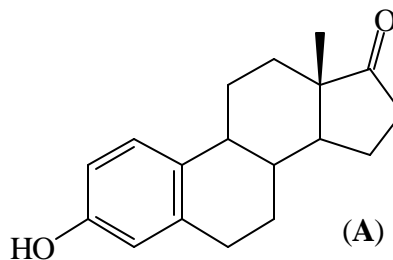
Give the molecular formula of estrone (**A**).

Identify the functional groups present in estrone (**A**).

How many stereogenic (chiral) centres are there in estrone (**A**)?

Treatment of estrone (**A**) with LiAlH$_4$ in dry ether (solvent) followed by aqueous acid gives (**B**). When (**B**) is warmed in concentrated H$_2$SO$_4$ and the resultant product is neutralised, compound (**C**) containing an alkene is obtained. Give constitutional formulas of (**B**) and (**C**).
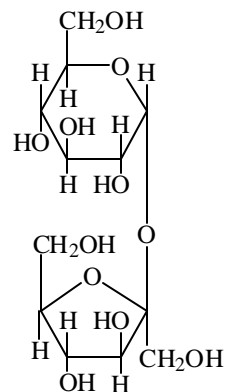
(**B**)

(**C**)

Reaction of estrone (**A**) with excess methanol and HCl gives an acetal (**D**). Give the constitutional formula of (**D**).

(**D**)

What are the reagents and reaction conditions that will convert the acetal (**D**) back to estrone and methanol.

Reagents and reaction conditions:

Marks

7

- Sucrose, α-D-glucopyranosyl-β-D-fructofuranoside, is table sugar. Its structure is shown on the right.

Does sucrose display "mutarotation"? Justify your answer.

Draw the Fischer projection of the open chain form of D-fructose.

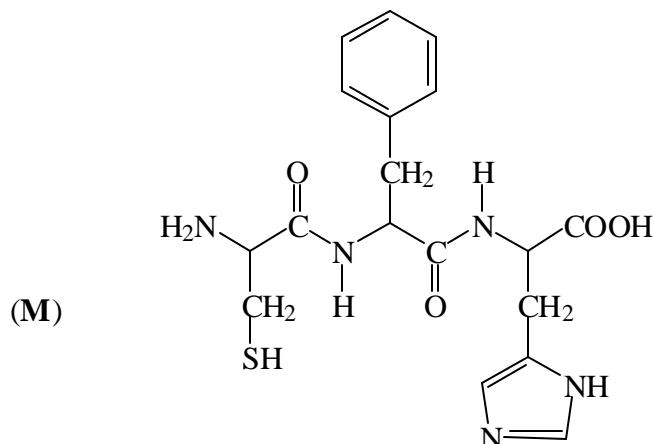D-Fructose, on treatment with acidified methanol, gives two furanosides. Draw the Haworth structures of these.

Draw the Haworth structure of the disaccharide 2-O-(β-D-glucopyranosyl)--β-D-glucopyranose.

• Consider the tripeptide L-cysteinyl-L-phenylalanyl-L-histidine (Cys-Phe-His) (**M**), whose constitutional formula is shown below.

Mark s

10

(**M**)

Draw the stereoformulas of the products obtained from the complete hydrolysis of (**M**) with 6 M HCl and indicate their absolute configurations using the (*R*)- and (*S*)- convention.

Absolute configuration		Absolute configuration		Absolute configuration	

The pK_a values of histidine are 1.81, 6.05 and 9.15. Give the structures of the predominant species present in a water solution of histidine at pH 7.6 and pH 11.0.
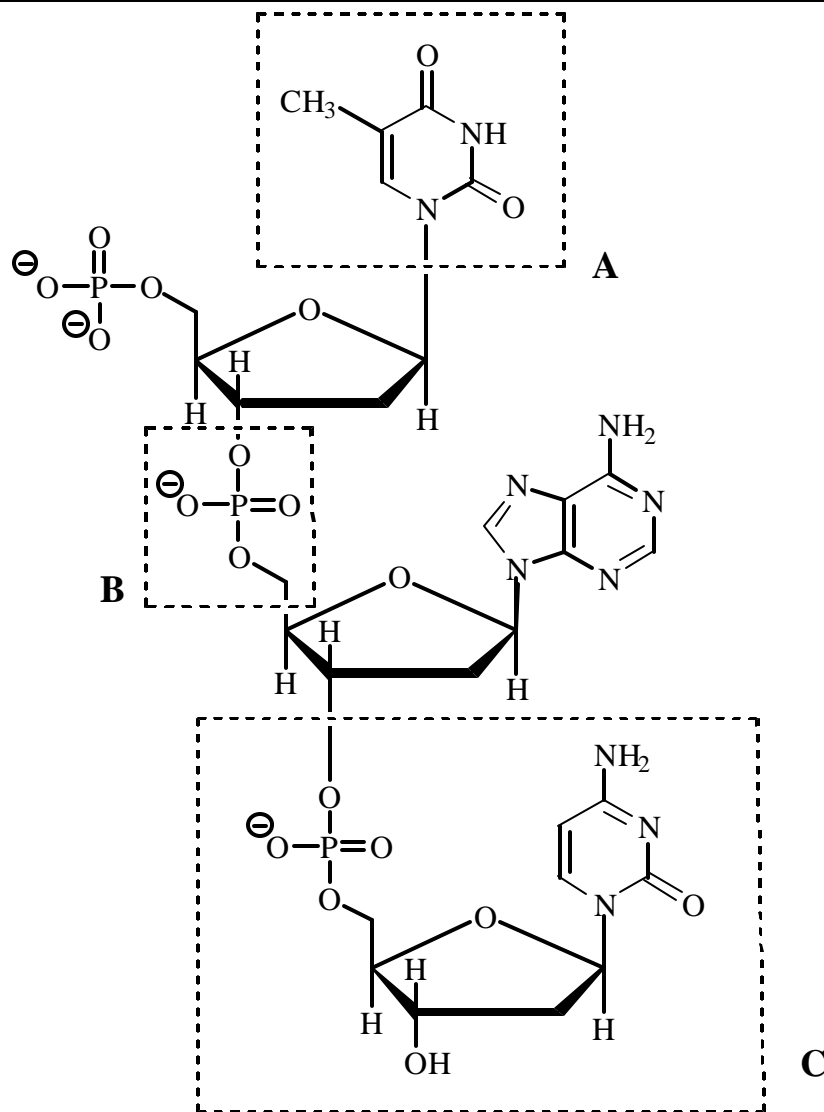
pH 7.6	pH 11.0

Give the constitutional formulas for the dipeptides Phe-Cys and His-Phe.

Phe-Cys	His-Phe

- Is the following trinucleotide a fragment of DNA or RNA? Give two reasons.

A

B

C

Give the <u>general</u> name of each of the indicated subunits within the structure.

A	
B	
C	

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Numerical Data

Physical constants

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

Speed of light in vacuum $= c_O = 3.00 \times 10^8$ m s^{-1}

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

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

$\qquad\qquad\qquad = 0.08206$ 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

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