Topics in the June 2006 Exam Paper for CHEM1611

Click on the links for resources on each topic.

2006-J-2:

- Assumed Knowledge
- Atomic Structure
- Chemical Bonding

2006-J-3:

- Assumed Knowledge

2006-J-4:

- Chemical Bonding
- The Shapes of Molecules
- Intermolecular forces

2006-J-5:

- Acids and Bases

2006-J-6:

- Aromatic Hydrocarbons
- Alcohols, Phenols, Ethers and Thiols

2006-J-7:

- Introduction to Organic Chemistry
- Aldehydes and Ketones
- Spectroscopy
- Stereochemistry

2006-J-8:

- Alkenes
- Organic Halogen Compounds
- Alcohols, Phenols, Ethers and Thiols
- Amines
- Aromatic Hydrocarbons
- Aldehydes and Ketones
- Carboxylic Acids and Derivatives

2006-J-9:

- Aldehydes and Ketones
- Carboxylic Acids and Derivatives

2006-J-10:

- Carbohydrates

2006-J-11:

- Introduction to Organic Chemistry

2006-J-12:

- Amino Acids, Peptides and Proteins

22/31(a)

The University of Sydney

CHEM1611 - CHEMISTRY 1A (PHARMACY)

FIRST SEMESTER EXAMINATION

CONFIDENTIAL

JUNE 2006 **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 16 pages of examinable material.
- Complete the written section of 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 table.
- 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.
- A Periodic Table and numerical values required for any question may be found on a separate data sheet.
- Pages 12, 15 & 20 are for rough working only.

OFFICIAL USE ONLY

Multiple choice section

	Marks	
Pages	Max	Gained
2-6	28	

Short answer section

Page	Marks: Max	Marks: Gained		Marker
7	9			
8	3			
9	7			
10	5			
11	6			
13	6			
14	9			
16	8			
17	7			
18	2			
19	10			
Total	72			

Marks

- Give the full electron configuration for the ground state K atom. **2**

What are the three quantum numbers that describe the orbital that contains the electron furthest from the nucleus in the K atom?

n =	l =	m_l =

- Draw the Lewis structures, showing all valence electrons for the following species. Indicate which of the species have contributing resonance structures. **4**

NCO^-	COF_2	NO_3^-
Resonance: YES / NO	Resonance: YES / NO	Resonance: YES / NO

- Human haemoglobin has a molar weight of 6.45×10^4 g mol^{-1} and contains 3.46 g of iron per kg. Calculate the number of iron atoms in each molecule of haemoglobin. **3**

Answer:

Marks
3

- If 50 mL of a 0.10 M solution of $AgNO_3$ is mixed with 50 mL of a 0.040 M solution of $BaCl_2$, what mass of AgCl(s) will precipitate from the reaction?

Answer:

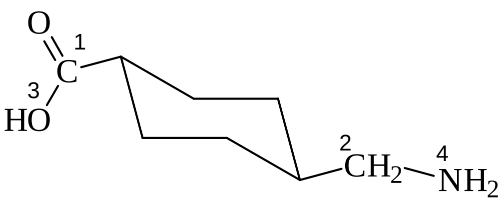
What is the concentration of NO_3^- ions in the final solution from the reaction above?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks
4

- Tranexamic acid, *trans*-(4-aminomethyl)cyclohexanecarboxylic acid, is used for the treatment of severe haemorrhage in patients with haemophilia.



Provide the requested information for each of the indicated atoms in tranexamic acid.

Atom	Geometric arrangement of the electron pairs around the atom	Hybridisation of the atom	Geometry/shape of σ-bonding electron pairs around the atom
C-1			
C-2			
O-3			
N-4			

3

- Consider the boiling points of the compounds 1-propanol, 1-propanethiol and 1-propaneselenol shown in the table below?

Compound	$CH_3CH_2CH_2OH$	$CH_3CH_2CH_2SH$	$CH_3CH_2CH_2SeH$
Boiling point (° C)	97.2	67.8	147.0

With reference to intermolecular forces, explain briefly why the boiling points increase in the order $CH_3CH_2CH_2SH$ < $CH_3CH_2CH_2OH$ < $CH_3CH_2CH_2SeH$.

Marks
5

- Consider the following equation.

$$HBrO(aq) + NH_3(aq) \rightleftharpoons BrO^-(aq) + NH_4^+(aq)$$

Name all of the species in this equation.

HBrO	
BrO^-	
NH_3	
NH_4^+	

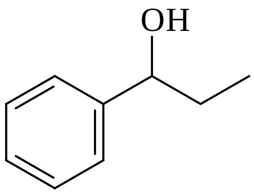
Complete the following table by giving the correct pK_a or pK_b value where it can be calculated. Mark with a cross (✕) those cells for which insufficient data have been given to calculate a value.

Species	HBrO	NH_3	BrO^-	NH_4^+
pK_a of acid	8.64			
pK_b of base		4.76		

Determine on which side (left or right hand side) the equilibrium for the reaction above will lie. Provide a brief rationale for your answer.

Marks
6

- 1-Phenyl-1-propanol (**J**) is treated with concentrated sulfuric acid to give a mixture of two alkenes (**K**) and (**L**). Alkenes (**K**) and (**L**) are diastereomers. Give the constitutional formulas for (**K**) and (**L**).

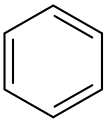


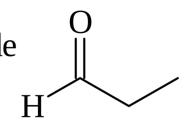
(**J**)

(**K**)	(**L**)

Give the structure of a constitutional isomer of (**J**).

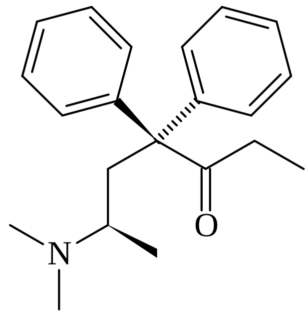
Outline a reaction sequence that converts benzene into 1-phenyl-1-propanol (**J**) and that also uses propionaldehyde as a reactant somewhere in the sequence. Any solvents and inorganic reagents may be used. More than one step is required. Show clearly the reagents you would use and draw constitutional formulas for any intermediate compounds.

benzene 

propionaldehyde (propanal) 

Marks
6

- A stick representation for the active enantiomer of methadone, an analgesic used as a maintenance drug in the treatment of heroin addiction, is shown below.



Give the molecular formula of methadone.

Methadone contains a stereogenic centre. List the substituents attached to this stereogenic centre in descending order of priority according to the sequence rules.

Highest priority Lowest priority

What is the stereochemistry at this stereocentre? Write (*R*) or (*S*).

List the functional groups present in methadone.

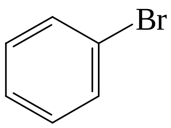
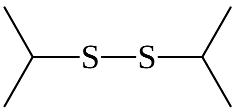
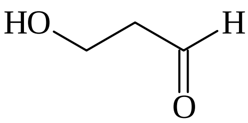
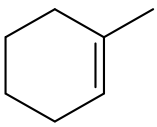
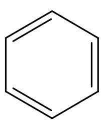
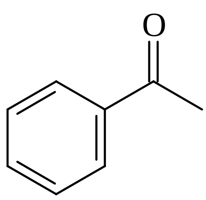
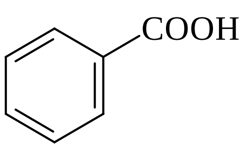
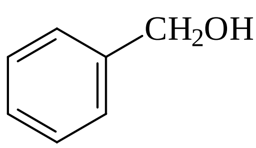
Treatment of methadone with $NaBH_4$ gives compounds (**X**) and (**Y**). Draw the structures of (**X**) and (**Y**).

(**X**)	(**Y**)

What is the stereochemical relationship between compounds (**X**) and (**Y**)?

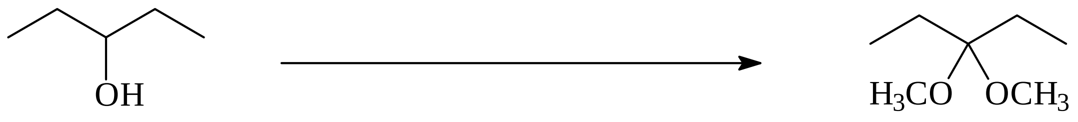
Marks 9

- Complete the following table.

STARTING MATERIAL	REAGENTS/ CONDITIONS	CONSTITUTIONAL FORMULA(S) OF MAJOR ORGANIC PRODUCT(S)
$CH_3CH_2CH_2Br$		$Br^{\ominus}$ $^{\oplus}N(CH_3)_3$ with $CH_2CH_2CH_3$ on N
	1. Mg / dry ether 2. CO_2 3. $H^{\oplus}$ / H_2O	
	Zn / $H^{\oplus}$	
	$[Ag(NH_3)_2]^{\oplus}$ / $OH^{\ominus}$	
$CH_3-C(=O)-OCH_2CH_2CH_3$	$H^{\oplus}$ / H_2O / heat	
	HBr / CCl_4 (solvent)	
		
		

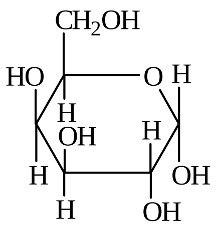
Marks
8

- Show clearly the reagents you would use to carry out the following chemical conversions. Draw constitutional formulas for any intermediate compounds. Note: More than one step is required in both cases.

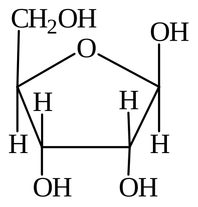


Marks
7

- Consider the following two monosaccharides **A** and **B**.



A: α-D-galactopyranose



B: β-D-ribofuranose

Give the Fischer projections of the open chain form of **A** and **B**.

Fischer projection of D-galactose	Fischer projection of D-ribose

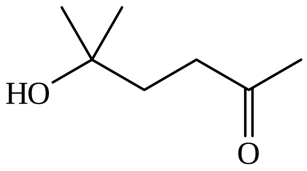
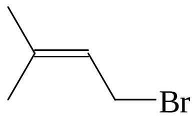
Give the products obtained when D-ribose is treated with the following reagents.

Acidified methanol	$NaBH_4$ in methanol solvent

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

Marks
2

- Name the following compounds.

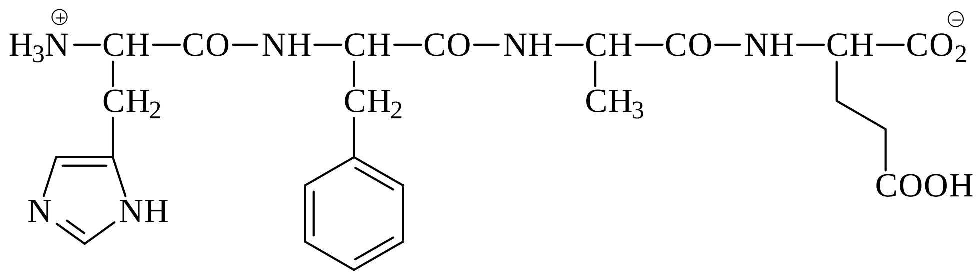
	
	

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks
10

- The structure of the naturally occurring tetrapeptide His-Phe-Ala-Glu, **A**, is shown below as the zwitterion.

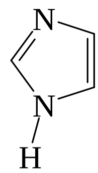
A



Give the product(s) obtained when **A** is treated with cold 1 M NaOH solution.

Give the Fischer projections of the four L-amino acids in their correct ionic states obtained from the vigorous basic hydrolysis (6 M KOH) of **A**.

The heterocycle present in the sidechain of histidine is imidazole, whose structure is shown on the right. Give the structure of the product formed when imidazole is treated with HCl. State, giving reasons, whether the product is aromatic.



What is the major species present when histidine is dissolved in water at pH 1. The pK_a values of histidine are 1.82 (-COOH), 9.17 (-$NH_3^{\oplus}$) and 6.04 (sidechain).

CHEM1611 - CHEMISTRY 1A (PHARMACY)

DATA SHEET

Physical constants

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

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

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

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

Rydberg constant, $E_R = 2.18 \times 10^{-18}$ J

Boltzmann constant, $k_B = 1.381 \times 10^{-23}$ J K^{-1}

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

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

Charge of electron, $e = 1.602 \times 10^{-19}$ C

Mass of electron, $m_e = 9.1094 \times 10^{-31}$ kg

Mass of proton, $m_p = 1.6726 \times 10^{-27}$ kg

Mass of neutron, $m_n = 1.6749 \times 10^{-27}$ kg

Properties of matter

Volume of 1 mole of ideal gas at 1 atm and 25 °C = 24.5 L

Volume of 1 mole of ideal gas at 1 atm and 0 °C = 22.4 L

Density of water at 298 K = 0.997 g cm^{-3}

Conversion factors

1 atm = 760 mmHg = 101.3 kPa

0 °C = 273 K

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

1 Å = 10^{-10} m

1 eV = 1.602×10^{-19} J

1 Ci = 3.70×10^{10} Bq

1 Hz = 1 s^{-1}

Decimal fractions

Fraction	Prefix	Symbol
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Decimal multiples

Multiple	Prefix	Symbol
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G

CHEM1611 - CHEMISTRY 1A (PHARMACY)

Standard Reduction Potentials, E°

Reaction	$E°$ / V
$Co^{3+}(aq) + e^- \rightarrow Co^{2+}(aq)$	+1.82
$Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq)$	+1.72
$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$	+1.50
$Cl_2 + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2 + 4H^+(aq) + 4e^- \rightarrow 2H_2O$	+1.23
$MnO_2(s) + 4H^+(aq) + e^- \rightarrow Mn^{3+} + 2H_2O$	+0.96
$Pd^{2+}(aq) + 2e^- \rightarrow Pd(s)$	+0.92
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$Cu^+(aq) + e^- \rightarrow Cu(s)$	+0.53
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	+0.15
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0 (by definition)
$Fe^{3+}(aq) + 3e^- \rightarrow Fe(s)$	–0.04
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	–0.13
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	–0.14
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.24
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$	–0.74
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$2H_2O + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	–0.83
$Cr^{2+}(aq) + 2e^- \rightarrow Cr(s)$	–0.89
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	–1.68
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.36
$Na^+(aq) + e^- \rightarrow Na(s)$	–2.71
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	–2.87
$Li^+(aq) + e^- \rightarrow Li(s)$	–3.04

CHEM1611 - CHEMISTRY 1A (PHARMACY)

Useful formulas

Quantum Chemistry $E = h\nu = hc/\lambda$ $\lambda = h/mv$ $4.5k_BT = hc/\lambda$ $E = Z^2E_R(1/n^2)$ $\Delta x\cdot\Delta(mv) \geq h/4\pi$ $q = 4\pi r^2 \times 5.67 \times 10^{-8} \times T^4$	**Electrochemistry** $\Delta G° = -nFE°$ $Moles\ of\ e^- = It/F$ $E = E° - (RT/nF) \times 2.303 \log Q$ $= E° - (RT/nF) \times \ln Q$ $E° = (RT/nF) \times 2.303 \log K$ $= (RT/nF) \times \ln K$ $E = E° - \frac{0.0592}{n} \log Q$ (at 25 °C)
Acids and Bases $pK_w = pH + pOH = 14.00$ $pK_w = pK_a + pK_b = 14.00$ $pH = pK_a + \log\{[A^-] / [HA]\}$	**Gas Laws** $PV = nRT$ $(P + n^2a/V^2)(V - nb) = nRT$
Colligative properties $\pi = cRT$ $P_{solution} = X_{solvent} \times P°_{solvent}$ $p = kc$ $\Delta T_f = K_f m$ $\Delta T_b = K_b m$	**Kinetics** $t_{½} = \ln 2/k$ $k = Ae^{-Ea/RT}$ $\ln[A] = \ln[A]_o - kt$ $\ln\frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$
Radioactivity $t_{½} = \ln 2/\lambda$ $A = \lambda N$ $\ln(N_0/N_t) = \lambda t$ ^{14}C age = $8033 \ln(A_0/A_t)$	**Thermodynamics & Equilibrium** $\Delta G° = \Delta H° - T\Delta S°$ $\Delta G = \Delta G° + RT \ln Q$ $\Delta G° = -RT \ln K$ $K_p = K_c (RT)^{\Delta n}$
Polymers $R_g = \sqrt{\frac{nl_0^2}{6}}$	**Mathematics** If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ $\ln x = 2.303 \log x$

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]