22/02(a) # The University of Sydney

FUNDAMENTALS OF CHEMISTRY 1B - CHEM1002

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**	

INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 14 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 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.
- Numerical values required for any question and a Periodic Table may be found on a separate data sheet.
- Pages 5, 15, 17, 19 & 20 are for rough working only.

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Multiple choice section

	Marks	
Pages	Max	Gained
2-10	48	

Short answer section

Page	Marks Max	Gained		Marker
11	12			
12	8			
13	7			
14	12			
16	7			
18	6			
Total	52			
Check Total				

Marks

- Complete the following table. **6**

Molecule	Number of electron pairs around central atom		Shape of molecule	Bond angle
	Sigma	Lone		
CH_4				
NH_3				
H_2O				

- Use the concept of effective nuclear charge (Z_{eff}) to explain why the atomic radii of atoms DECREASE across any period, yet INCREASE down a group, in the periodic table. **2**

- Why is the N≡N bond stronger than the C≡C bond? **2**

- Distinguish between the terms “end point” and “equivalence point” in reference to a titration. **2**

- (i) Write the electron configuration for the titanium atom.

Marks
5

Titanium(IV) chloride dissolves in concentrated hydrochloric acid to give the complex ion $[TiCl_6]^{2-}$.

(ii) What is the oxidation number of the titanium in $[TiCl_6]^{2-}$?

(iii) What is the coordination number of the titanium in $[TiCl_6]^{2-}$?

(iv) What is the shape of the $[TiCl_6]^{2-}$ ion?

(v) Write the electron configuration for the titanium ion present in the $[TiCl_6]^{2-}$ ion.

(vi) Would you expect the $[TiCl_6]^{2-}$ ion to be coloured? Explain!

- What is the pH of the solution obtained by adding 60.0 mL of 0.10 M NaOH to 50.0 mL of 0.10 M HCl?

3

ANSWER:

Marks 7

- Calculate the pH of the following solutions in water at 25 °C. Give your answers to 2 decimal places. Relevant pK_a data are on the separate data sheet.

Benzoic acid (0.010 M)

ANSWER:

A buffer solution made up of acetic acid (0.050 M) and sodium acetate (0.10 M).

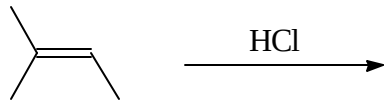
ANSWER:

Ammonia (0.10 M) (Hint: ammonia is a base)

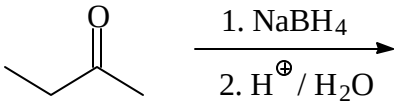
ANSWER:

- Give the name of the starting material where requested and the constitutional formula(s) of the major organic product(s) formed in each of the following reactions.

Marks **6**



Name:



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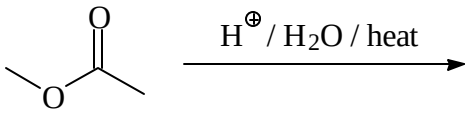
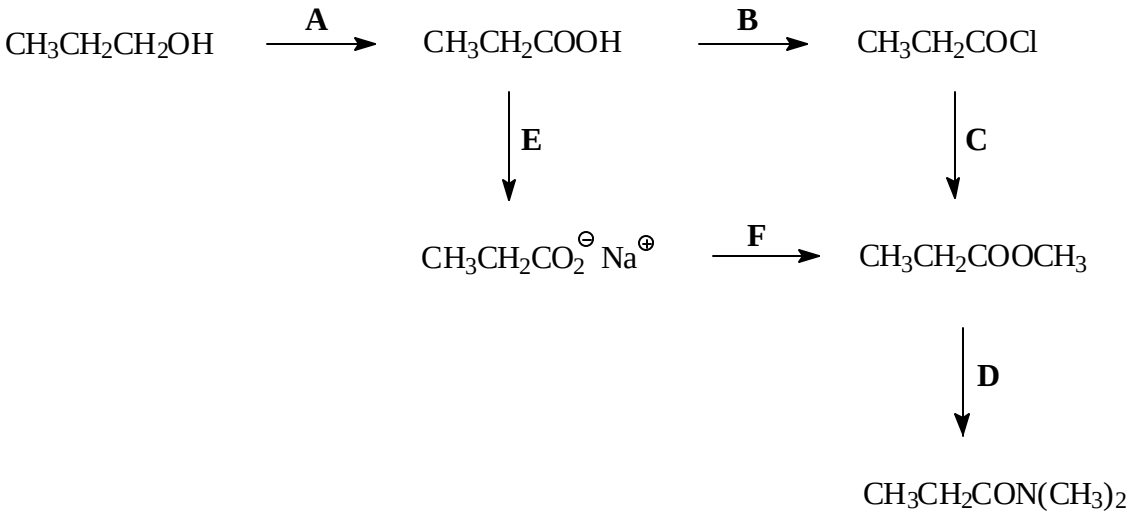


- Indicate the reagents required to undertake the following transformations.

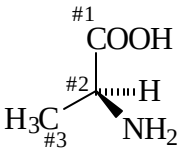
6



A:	**D:**
B:	**E:**
C:	**F:**

Marks 7

- Alanine is a naturally occurring amino acid with the structure shown below.



Indicate the hybridisation of all carbon atoms in alanine.

#1	#2	#3

What is the configuration of alanine in the above structure?
Write (*R*) or (*S*).

Write the product of alanine with the following reagents.

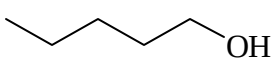
dilute HCl	dilute NaOH

Alanine has a melting point of 297 °C, much higher than expected for a typical organic compound of this molecular mass. Suggest a reason for this.

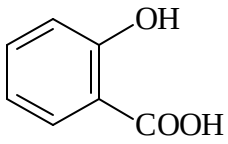
Draw the structure(s) that show how alanine may form part of a polymer with other amino acids.

Marks 6

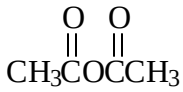
- In experiment E29, esters are formed by the reaction of acetic anhydride with compounds **Y** and **Z**.



Y



Z



acetic anhydride

Give the systematic name for compound **Y**.

Name the functional groups present in compound **Z**.

Draw the constitutional formula(s) of the product(s) from the reaction of acetic anhydride with compound **Z**.

Experimentally, excess acetic anhydride is decomposed by hydrolysing it with water. What is the product of this hydrolysis reaction?

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Numerical Data

Conversion factors

1 mL = 10^{-3} L

Acid ionisation constants at 298 K

Acid	Formula	pK_a
ammonium ion	NH_4^+	9.24
acetic acid	CH_3COOH	4.76
benzoic acid	C_6H_5COOH	4.20

Henderson-Hasselbalch equation

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

Useful formulas

$pK_w = pK_a + pK_b = 14.00$

$pK_w = pH + pOH = 14.00$

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]