ANSWERS

CHRIST CHURCH GRAMMAR SCHOOL

Year 12 Chemistry
Trial Exam 2006

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes
Working time for the paper: Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

Pens, pencils, calculator satisfying the conditions set by Curriculum Council.

STRUCTURE OF THE PAPER

Part	Format	No. of questions set	No. of questions to be attempted	Recommended time (minutes)	Marks Allocated	Marks
1	Multiple Choice	30	ALL	55	60 (30%)	
2	Short Answer	11	ALL	60	70 (35%)	
3	Calculations	5	ALL	45	50 (25%)	
4	Extended Response	1	ONE	20	20 (10%)	

Total = /200

CHEMICAL EQUATIONS

For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^+(aq)$], **molecules** [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(l)$] or **solids** [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$]

Place your student identification

label in this box

CHRIST CHURCH GRAMMAR SCHOOL

MULTIPLE CHOICE ANSWER SHEET

Year 12 Chemistry Trial Exam 2006

NAME : ANSWERS. TEACHER: ____________

Answer all multiple choice questions on this sheet by crossing out one of the letters e.g. [A] [B] [C] ~~[D]~~

1	[A]	~~[B]~~	[C]	[D]
2	[A]	[B]	~~[C]~~	[D]
3	[A]	~~[B]~~	[C]	[D]
4	[A]	[B]	~~[C]~~	[D]
5	[A]	[B]	~~[C]~~	[D]
6	[A]	[B]	[C]	~~[D]~~
7	[A]	[B]	[C]	~~[D]~~
8	~~[A]~~	[B]	[C]	[D]
9	~~[A]~~	[B]	[C]	[D]
10	[A]	[B]	~~[C]~~	[D]
11	[A]	[B]	~~[C]~~	[D]
12	~~[A]~~	[B]	[C]	[D]
13	[A]	~~[B]~~	[C]	[D]
14	[A]	[B]	~~[C]~~	[D]
15	[A]	[B]	[C]	~~[D]~~

16	~~[A]~~	[B]	[C]	[D]
17	[A]	[B]	[C]	~~[D]~~
18	[A]	~~[B]~~	[C]	[D]
19	[A]	[B]	~~[C]~~	[D]
20	[A]	[B]	~~[C]~~	[D]
21	[A]	[B]	[C]	~~[D]~~
22	[A]	[B]	~~[C]~~	[D]
23	~~[A]~~	[B]	[C]	[D]
24	[A]	[B]	[C]	~~[D]~~
25	[A]	~~[B]~~	[C]	[D]
26	[A]	[B]	~~[C]~~	[D]
27	[A]	~~[B]~~	[C]	[D]
28	~~[A]~~	[B]	[C]	[D]
29	[A]	[B]	~~[C]~~	[D]
30	[A]	[B]	~~[C]~~	[D]

Mark = $\frac{\quad}{30}$ = $\frac{\quad}{60}$

PART 1 (60 marks = 30% of paper)

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet provided. Each question in this part is worth 2 marks.

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1. Which of the following species have the same electron configuration?

I	Ar
II	Sc^{3+}
III	$^{35}Cl^-$
IV	$^{37}Cl^-$

A. None of them.

B. All of them.

C. I and II only.

D. III and IV only.

2. Which list of elements is arranged in order of increasing atomic radius?

A. potassium, aluminium, chlorine, fluorine.

B. fluorine, aluminium, chlorine, potassium

C. fluorine, chlorine, aluminium, potassium.

D. potassium, chlorine, aluminium, fluorine.

3. Which of the pairs of elements, described in terms of their electron configurations, will combine with each other to form **ionic bonds**?

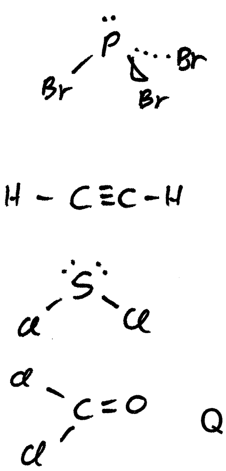
I	$1s^2\ 2s^2\ 2p^3$	$1s^2\ 2s^2\ 2p^4$
II	$1s^2\ 2s^2\ 2p^5$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
III	$1s^2\ 2s^2\ 2p^2$	$1s^2\ 2s^2\ 2p^4$
IV	$1s^2\ 2s^2\ 2p^6\ 3s^1$	$1s^2\ 2s^2\ 2p^5$
V	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

A. I and II only.

B. IV only.

C. I, II and III.

D. IV and V.



4. Which of the following represents the correct shapes of each of the molecules PBr_3, HCCH, Cl_2S and Cl_2CO respectively as shown?

	PBr_3	HCCH	Cl_2S	Cl_2CO
A.	pyramidal	bent	bent	pyramidal
B.	trigonal planar	bent	linear	pyramidal
C.	pyramidal	linear	bent	trigonal planar
D.	trigonal planar	linear	linear	trigonal planar

Questions 5 and 6 refer to the ionisation energies of two elements X and Y.

5. Consider the following successive ionisation energies of an element X.

Ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionisation Energy (kJ mol^{-1})	1,310	3,390	5,320	7,450	11,000	13,300	71,000	91,600

The group this element belongs to, and the charge on its most common and stable ion, would be:

A. group V and 3–

B. group V and 5+

C. group VI and 2-

D. group I and 1+

6. The successive ionisation energies of an element Y are:

Ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionisation Energy (kJ mol^{-1})	577	1,820	2,740	11,600	14,800	18,400	23,400	27,500

The compound formed between X and Y would most likely be:

A. A covalent compound of formula Y_3X_2

B An ionic compound of formula Y_3X_2

C A covalent compound of formula Y_2X_3

D. An ionic compound of formula Y_2X_3

7. Which of the following lists the four substances in order of increasing melting points?

A. SiO_2, CO_2, O_2, He

B. He, O_2, SiO_2, CO_2

C. He, CO_2, O_2, SiO_2

(D.) He, O_2, CO_2, SiO_2

8. Which of the following compounds can form hydrogen bonds?

✓ I H_2O
✓ II H_2O_2
✗ III CH_3COCH_3
✓ IV C_2H_5OH

(A.) I,II and IV.

B. II and III.

C. I, III and IV.

D. all of them.

9. The values of *a* and *b* in the following redox equation are:

$a VO_2^+ \quad + \quad b Al \quad + \quad c H^+ \; \text{-->} \; d VO^{2+} \quad + \quad e Al^{3+} \quad + \quad 3H_2O$

(A.) *a* = 3 , *b* = 1

B. *a* = 3 , *b* = 2

C. *a* = 2 , *b* = 3

D. *a* = 1 , *b* = 3

$VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O \quad (\times 3)$

$Al \rightarrow Al^{3+} + 3e^-$

$3VO_2^+ + 6H^+ + Al \rightarrow 3VO^{2+} + 3H_2O + Al^{3+}$

10. Which of the following are endothermic reactions?

I $6CO_{2(g)} + 6H_2O_{(l)}$ --> $C_6H_{12}O_{6(s)} + 6O_{2(g)}$ ✓
II $C_2H_5OH_{(g)}$ --> $C_2H_5OH_{(l)}$ ✗
III $2Al_2O_{3(s)}$ --> $4Al_{(s)} + 3O_{2(g)}$ ✓
IV $H^+_{(g)} + H^-_{(g)}$ --> $H_{2(g)}$ ✗

A. I and II.

B. I, II and III.

(C.) I and III.

D. II and III.

Questions 11 to 14 refer to the equilibrium reaction:

$$Co(H_2O)_6^{2+}{}_{(aq)} + 4Cl^-{}_{(aq)} \rightleftharpoons CoCl_4^{2-}{}_{(aq)} + 6H_2O_{(l)} \qquad \Delta H=+ve$$

$Co(H_2O)_6^{2+}{}_{(aq)}$ is pink whilst $CoCl_4^{2-}{}_{(aq)}$ is blue. A solution contains equal concentrations of both of these ions.

11. What will be the effect of increasing the temperature on the colour and the value of the equilibrium constant K?

A. K increases and the mixture becomes more pink.
B. K decreases and the solution becomes more pink.
C. K increases and the solution becomes more blue.
D. K decreases and the solution becomes more blue.

12. What change could make the solution become more pink in colour, without changing the value of K?

A. Add some water.
B. Heat it to evaporate some water. x
C. Increase the pressure. x
D. Add some solid NaCl. x

13. Adding some concentrated $AgNO_{3(aq)}$ will have which of the following effects?

	Rate of forwards reaction	Rate of backwards reaction
A.	does not change	does not change
B.	decreases	decreases
C.	increases	decreases
D.	decreases	increases

14. If a suitable solid catalyst can be found for the reaction and is added to the reaction mixture, what will be the effects on the following?

	Value of K	Rate of forwards reaction	Rate of backwards reaction
A.	does not change	does not change	does not change
B.	increased	does not change	does not change
C.	does not change	increased	increased
D.	increased	increased	increased

15. The ionisation of water is an endothermic process. The ionisation constant (K_w) for this reaction is 1.00×10^{-14} at 25°C. Which of the following best describes a sample of pure water at 50°C?

A. An acidic solution with a pH of less than 7.
B. A neutral solution with a pH of 7.
C. A neutral solution with a pH of greater than 7.
(D.) A neutral solution with a pH of less than 7.

↑ TEMP
SHIFT TO RIGHT
∴ ↑[H^+], ↑[OH^-]
NEUTRAL ([H^+] = [OH^-]).
pH < 7

Questions 16 to 18 refer the following

Oxalic acid, HOOCCOOH, is a diprotic weak acid. 20.0 mL of oxalic acid solution is accurately titrated with 0.100 mol L^{-1} NaOH and the end point is reached after the addition of 21.75 mL of the NaOH. The end point occurred exactly at the equivalence point.

HOOCCOOH + $2OH^-$ → $^-OOCCOO^-$ + $2H_2O$

16. What is the concentration of the oxalic acid solution?

(A.) 0.0544 mol L^{-1}
B. 0.109 mol L^{-1}
C. 0.2175 mol L^{-1}
D. 0.0109 mol L^{-1}

n(OH^-) = n(NaOH) = (0.1)(0.02175)
= 0.00218 mol
n(HOOCCOOH) = ½ n(OH^-) = 0.00109 mol
[HOOCCOOH] = n/V = 0.00109/0.02 = 0.0544M

17. What would be the most likely pH of the reaction mixture at the end point?

A. 13
B. 5
C. 7
(D.) 9

OXALATE ION ($^-OOCCOO^-$) IS BASIC
∴ END POINT WILL BE WEAKLY BASIC
DUE TO
$^-OOCCOO^-$ + $2H_2O$ ⇌ HOOCCOOH + $2OH^-$

18. Pure oxalic acid is a white solid with a melting point of 187°C. Which of the following best describes the bonding within the solid?

	Intramolecular Forces	Intermolecular Forces	Polarity of molecule
A.	covalent bonds	van der Waals'	polar
(B.)	covalent bonds	hydrogen bonds	polar
C.	hydrogen bonds	covalent bonds	non-polar
D.	covalent bonds	hydrogen bonds	non-polar

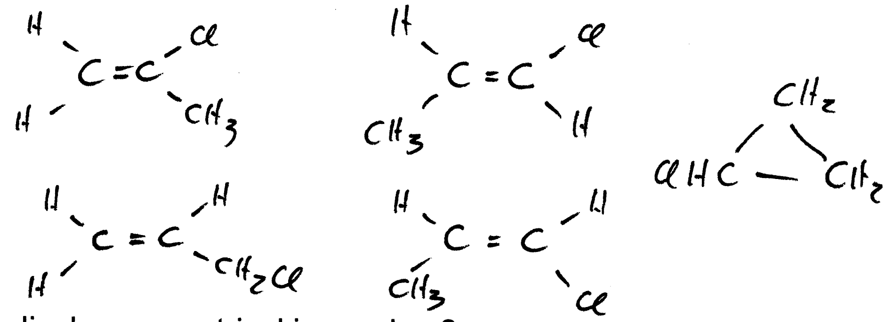
19. How many isomers are there of C_3H_5Cl?

A. 3

B. 4

C. 5

D. 6



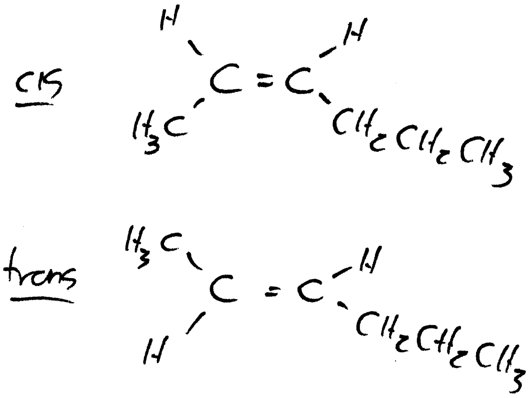
20. Which of the following display geometrical isomerism?

I 1,2-dibromohexane

II 2,3-dimethylpentane

III 1-hexene

IV 2-hexene



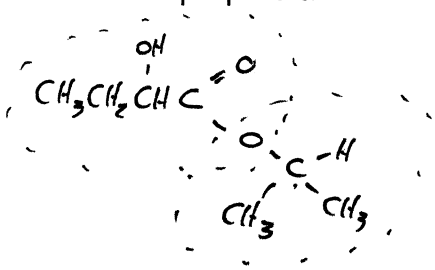
A. II, II and IV.

B. II and IV.

C. IV only.

D. all four of them.

21. Which of the following pairs of substances could be used to prepare a sample of $CH_3CH_2CH(OH)COOCH(CH_3)_2$?



A. 2-methylpropanoic acid and 2-butanol.

B. 3-hydroxybutanoic acid and 1-propanol.

C. 2-hydroxypropanoic acid and 2-butanol.

D. 2-hydroxybutanoic acid and 2-propanol.

22. Which monomers could be used to prepare a condensation polymer?

A. C_2H_5OH and CH_3COOH

B. CH_2CH_2 and CH_2CHCH_3

C. $HOCH_2CH_2OH$ and $HOOCCOOH$

D. $HOOCCOOH$ and $HCOCHO$

23. Which of the following could be oxidised to a ketone using acidified potassium dichromate? ∴ 2° alcohol

(A) cyclohexanol ✓ 2°

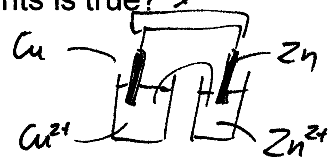
B. 2-methyl-2-propanol ✗ 3°

C. methanol ✗ 1°

D. ethanol ✗ 1°

24. Consider the electrochemical cell set up between the Cu/Cu^{2+} and Zn/Zn^{2+} half cells, under standard conditions with a potassium nitrate solution salt bridge. Which of the following statements is true?

ox $Zn \rightarrow Zn^{2+} + 2e^-$
red $Cu^{2+} + 2e^- \rightarrow Cu$
1.10V



A. the overall cell voltage is 0.43V. ✗

B. the copper electrode is the anode. ✗

C. electrons in the wire flow from the Cu electrode to the Zn electrode. ✗

(D) potassium ions in the salt bridge flow from the Zn/Zn^{2+} half cell to the Cu/Cu^{2+} half cell. ✓ cations flow towards cathode

25. Which of the following are disproportionation reactions?

I	$BrO_3^- + 5Br^-$	-->	$3Br_2 + 3H_2O$	
II	$2H_2O_2$	-->	$2H_2O + O_2$	✓
III	$3NO_2 + H_2O$	-->	$2HNO_3 + NO$	✓
IV	$2Cu^+$	-->	$Cu^{2+} + Cu$	✓

A. All of them.

(B) II, III and IV.

C. I, II and IV.

D. II and III.

26. Which of the following contains species listed in order of increasing oxidation state of sulfur?

A. $S_2O_3^{2-}$, $S_4O_6^{2-}$, SO_4^{2-}, SO_3^{2-}

B. SO_4^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, $S_4O_6^{2-}$

(C) $S_2O_3^{2-}$, $S_4O_6^{2-}$, SO_3^{2-}, SO_4^{2-}

D. $S_4O_6^{2-}$, $S_2O_3^{2-}$, SO_3^{2-}, SO_4^{2-}

$S_2O_3^{2-}$ +2
$S_4O_6^{2-}$ +2.5
SO_3^{2-} +4
SO_4^{2-} +6

27. Which of the following can convert iron(II) ions in water to iron(III) ions?

I	Bromine dissolved in water ✓
II	Potassium chloride solution ✗
III	Zinc metal ✗
IV	A solution containing both potassium dichromate and sulfuric acid ✓

A. I and II only.

(B.) I and IV only.

C. II and III only.

D. III and IV only.

28. Mercury oxide-zinc batteries are used in many low power applications such as watches and calculators. The cell reaction is:

$HgO(s) + Zn(s) + H_2O(l) \rightarrow Hg(l) + Zn(OH)_2(s)$

+2 0 0 +2

The half-cell reaction at the positive electrode of the battery is: ∴ CATHODE ⇒ REDUCTION.

(A) $HgO(s) + H_2O(l) + 2e^- \rightarrow Hg(l) + 2OH^-(aq)$

B. $Hg(l) + 2OH^-(aq) \rightarrow HgO(s) + H_2O(l) + 2e^-$ ✗

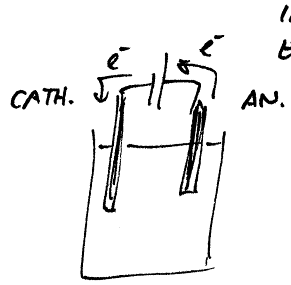
C. $Zn(OH)_2(s) + 2e^- \rightarrow Zn(s) + 2OH^-(aq)$

D. $Zn(s) + 2OH^-(aq) \rightarrow Zn(OH)_2(s) + 2e^-$ ✗

29. What will be the products at each electrode during the electrolysis of 1.0 mol L^{-1} aqueous potassium iodide?

ASSUME INERT ELECTRODES

	Cathode product	Anode product
A.	iodine	hydrogen
B.	hydrogen	oxygen
(C)	hydrogen	iodine
D.	potassium	iodine



CATH $K^+_{(aq)} + e^- \rightarrow K_{(s)}$ ✗

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ ✓

AN $2I^- \rightarrow I_2 + 2e^-$ ✓

$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ ✗

30. When Freddie Flintoff celebrates England's Ashes victory at Sydney in January, he will choose a bottle of champagne containing 14% ethanol by mass. Assuming the champagne has a density of 1.00 kg L^{-1}, what is the concentration of ethanol (in mol L^{-1}) in the champagne?

A. 1.40×10^{1} mol L^{-1}

B. 0.330 mol L^{-1}

(C) 3.00 mol L^{-1}

D. 1.40 mol L^{-1}

1L HAS MASS 1kg

m(ethanol) = 14/100 × 1 = 0.140kg = 140g

n (ethanol) = m/M = 140/46.068
CH_3CH_2OH
= 3.04 molL^{-1}

End of Part 1

PART 2 (70 marks = 35% of paper)

Answer ALL questions in Part 2 in the spaces provided below.

1. Write equations for any reactions that occur in the following procedures. If no reaction occurs write 'no reaction'.

   In each case describe in full what you would observe, including any colours, odours, precipitates (give the colour) and gases evolved (give the colour or describe as colourless). If no change is observed you should state this.

   a) Dilute hydrochloric acid is added to sodium hydrogencarbonate crystals.

   Equation $H^+(aq) + NaHCO_3(s) \rightarrow Na^+(aq) + H_2O(l) + CO_2(g)$ (2)

   Observation White solid dissolves, bubbling, colorless, odourless gas evolved. (1)

   b) Pieces of chromium are added to 6 mol L^{-1} sodium hydroxide solution.

   Equation $2Cr(s) + 2OH^-(aq) + 6H_2O(l) \rightarrow 2[Cr(OH)_4]^-(aq) + 3H_2(g)$ (2)

   Observation Silver solid dissolves to give deep green solution, Bubbling - cless, olless gas evolved (1)

   c) Excess ammonia solution is added to zinc nitrate solution.

   Equation $Zn^{2+}(aq) + 4NH_3(aq) \rightarrow [Zn(NH_3)_4]^{2+}$ (2)

   Observation white precipitate formed which redissolves. (1)

   (2 equations also accepted)

   d) Ethanol and methanoic acid are heated together with a small amount of sulfuric acid.

   Equation $CH_3CH_2OH + HCOOH \xrightarrow{H^+} HCOOCH_2CH_3 + H_2O$ (2)

   Observation Fruity smell develops (1)

[4 x 3 = 12 marks]

2. The electron configuration of a lithium atom is $1s^22s^1$. Using the same notation, give the electron configuration of:

a) a halogen atom in period 3 $1s^22s^22p^63s^23p^5$ (1)

b) an excited sodium ion $1s^22s^22p^54s^1$ (any excited ion) (1)

[2 marks]

3. A colourless solution with pH = 1.0 is added to a colourless solution with pH =11 producing a white precipitate. Write an equation for this reaction.

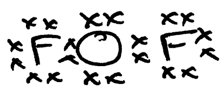
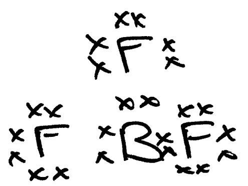
$2H^+ + 2OH^- + Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4 + 2H_2O$ (2)

[2 marks]

4. For each of the species listed in the table below:

a) draw the structural formula, representing all valence shell electron pairs as either : or –

b) indicate the shape and polarity of each species by either a sketch or a name

Species	Structural Formula	Shape	Molecular polarity
OF_2	 (2)	bent (1)	polar (1)
BF_3	 (2)	Trigonal planar (1)	non-polar (1)

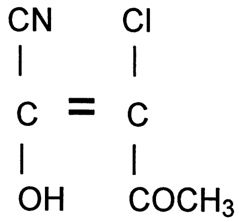
[2 x 4 = 8 marks]

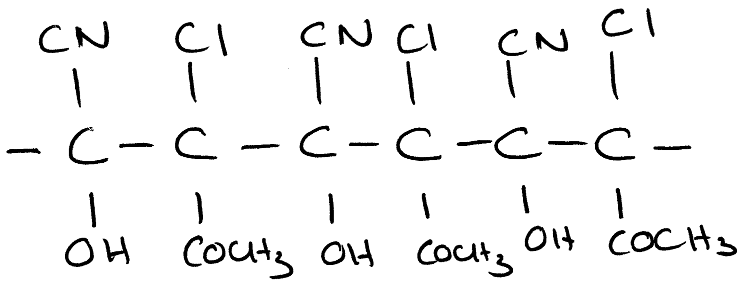
5. For each of the following pairs of chemicals describe fully a chemical test that could be used to distinguish between the two substances. Provide observations for each substance.

Substances	Full description	Observations
calcium carbonate and zinc carbonate solids	(1) Add $HCl_{(aq)}$ (1) (2) Add excess $NaOH_{(aq)}$ (1)	calcium carbonate (1) Bubbling, white solid dissolves (2) white ppt (1)
		zinc carbonate (1) Bubbling, white solid dissolves (2) White ppt which redissolves (1)
methyl butanoate and butanoic acid	Add Na_2CO_3 (or Na, $NaHCO_3$ many possible) (1)	methyl butanoate NVR (1)
		butanoic acid Bubbling - cless, olless gas evolved white solid dissolves (1)

[~~2×3~~ = ~~6~~ marks]
4+3 7

6. Draw a piece of the polymer that would be produced from the monomer below. Show at least 3 monomers in your answer:





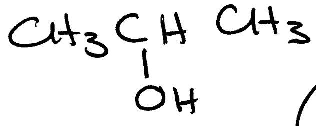
2

[2 marks]

7. For each of the following reactions draw the full structural formula of the main organic products.

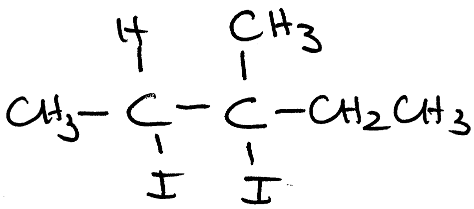
a) 2-propyl ethanoate is boiling with sodium hydroxide

CH_3COO^- (1)



(1)

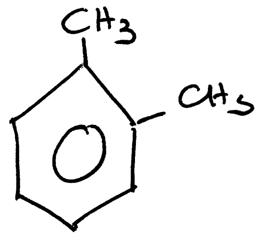
b) Iodine water is added to 3-methyl-2-pentene.



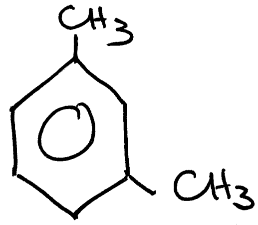
(1)

[3 x 1 = 3 marks]

7. c) Draw the structural formula of 2 aromatic isomers of C_8H_{10}.



(1)



(1)

or 1,4 dimethyl benzene

d) Name the following molecules:

i) $CHCCH_2CH_3$

1-butyne (1)

ii) $(CH_3)_2CHCH_2COCH_3$

(1)

4-methyl-2-pentanone

[4 x 1 = 4 marks]

8. Using equations in your answer, explain why a solution of $NH_4CH_3COO(aq)$ has a pH = 6.28.

NH_4CH_3COO dissociated in H_2O and both ions undergo hydrolysis (1)

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ (1)

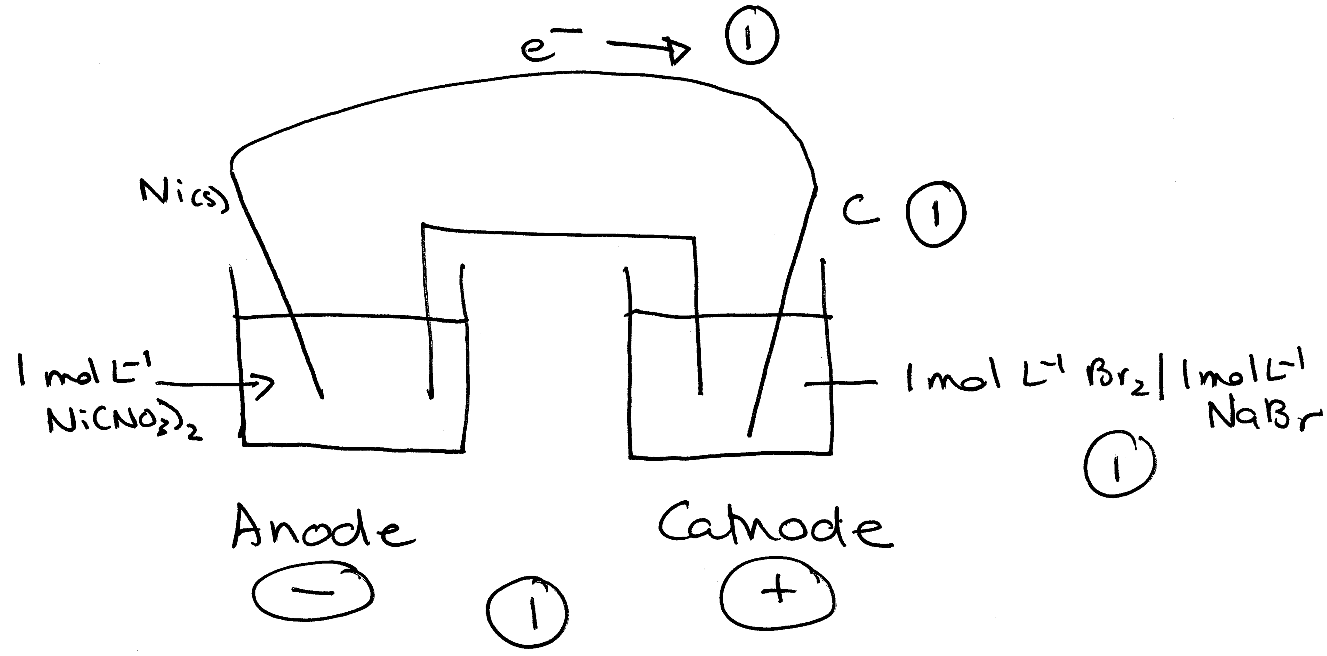
$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$

pH of 6.28 indicates acidic solution with excess H_3O^+ (1)

∴ Hydrolysis of NH_4^+ must occur to greater extent than CH_3COO^- (1)

[5 marks]
4 5

9. a) Consider the construction of an electrochemical cell using $Ni(s)/Ni^{2+}(aq)$ and $Br^{-}(aq)/Br_2(aq)$. Sketch a diagram of such an electrochemical cell, labeling the cathode and anode and showing the electrolytes used, electrodes used, polarity of electrodes and flow of electrons.



b) What is the EMF of this cell under standard conditions?

+1·33V (1)

c) Write the anode reaction.

$Ni_{(s)} \rightarrow Ni^{2+} + 2e^-$ (1)

d) State your expected observation at the cathode.

Solution becomes less red/brown (1)

e) Why would $Na_2CO_3(aq)$ be unsuitable for use in the salt bridge?

CO_3^{2-} ion would precipitate with Ni^{2+} (1)

[4+1+1+1+2 = 8 marks]

10. Consider the following chemical equilibrium system:

$$4\ HCl(g) + O_2(g) \rightleftharpoons 2\ H_2O(g) + 2\ Cl_2(g) + 113\ kJ$$

In each of the following cases, decide whether the proposed change will result in an increase or decrease in both the rate of attainment of equilibrium and the equilibrium yield of $Cl_2(g)$.

a) The volume of the container is halved at constant temperature:

i) rate of attainment increase (1)

ii) equilibrium yield increase (1)

b) The temperature of the mixture is raised:

i) rate of attainment increase (1)

ii) equilibrium yield decrease (1)

c) Additional HCl(g) is added:

i) rate of attainment increase (1)

ii) equilibrium yield increase (1)

[6 x 1 = 6 marks]

d) In (a) above, explain the effect that halving the volume will have on the $[O_2]$ and the mass of O_2.

i) $[O_2]$ WILL INCREASE SINCE PRESSURE HAS INCREASED AND SYSTEM WILL SHIFT TO RIGHT TO OPPOSE CHANGE. SOME O_2 WILL BE 'USED UP' IN SHIFT BUT $[O_2]$ WILL REMAIN HIGHER THAN ORIGINAL. (1) (1)

ii) Mass of O_2 WILL DECREASE DUE TO SHIFT IN EQUILIBRIUM TO RIGHT, MEANING LESS O_2 THAN AT INITIAL EQUILIBRIUM. (1) (1)

[2 x 2 = 4 marks]

11. a) Rank the following in order of decreasing boiling point. In the table write "1" for the compound with the highest boiling point, down to "4" for the compound with the lowest boiling point.

Compound	Boiling points in order (1 = highest, 4 = lowest)
$CH_3CH_2CH_2CH_2CHO$	2
$CH_3(CH_2)_4OH$	1
$CH_3(CH_2)_4CH_3$	3
$CH_3(CH_2)_2CH(CH_3)_2$	4

[2 marks]

b) Explain your ranking using appropriate chemical theory.

$CH_3(CH_2)_4OH$ – alcohol, hydrogen (1) bonding – strong type of dipole-dipole force ∴ more energy required to break (1) intermolecular forces

$CH_3CH_2CH_2CH_2CHO$ – aldehyde, slightly (1) polar ∴ dipole-dipole forces

$CH_3(CH_2)_4CH_3$ and $CH_3(CH_2)_2CH(CH_3)_2$ both nonpolar ∴ dispersion forces only (1)

$CH_3(CH_2)_2CH(CH_3)_2 < CH_3(CH_2)_4CH_3$ as branched ∴ less SA contact between molecules (1) and weaker dispersion forces

[5 marks]

End of Part 2

PART 3 (50 marks = 25% of paper)

Answer ALL questions in Part 3. The calculations are to be set out in detail in this Question/Answer booklet. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. When questions are divided into sections, clearly distinguish each section using (a), (b), and so on. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't, you will lose marks.

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1. One industrial preparation of hydrogen peroxide involves the electrolysis of cold ammonium sulfate in sulfuric acid. The electrode reactions are:

ANODE:	$2HSO_4^-$	→	$S_2O_8^{2-} + 2H^+ + 2e^-$
CATHODE:	$2H^+ + 2e^-$	→	H_2

In this process the peroxydisulfate ion formed at the anode is hydrolysed to give hydrogen peroxide:

$$S_2O_8^{2-} + 2H_2O \rightarrow 2HSO_4^- + H_2O_2$$

a) If a current of 300 amperes is passed through the electrolyte for one and a half hours, what mass of hydrogen peroxide would be formed if the electrolysis is 100% efficient and the conversion of peroxydisulfate ion to hydrogen peroxide is 50% efficient? [5 marks]

b) Calculate the volume of hydrogen produced at the cathode at 95°C and 105 kPa. [3 marks]

(a) $Q = I \times t$

$= 300 \times 90 \times 60$ (1)

$= 1620000$ C

$n_{e^-} = \frac{q}{96490} = \frac{1620000}{96490} = 16.789$ (1)

using anode eqn: $n_{S_2O_8^{2-}} = \frac{1}{2} n_{e^-} = 8.3946$ (1)

using full eqn: $n_{H_2O_2} = n_{S_2O_8^{2-}} = 8.3946$

$m_{H_2O_2} = 8.3946 \times 34.016 = 285.55$ g (1)

true $m_{H_2O_2} = \frac{50}{100} \times 285.5518 = 143$ g (1)

1. cont.

(b) $n_{H_2} = \frac{1}{2} n e^-$

$= 8.3946$ (1)

$V_{H_2} = \frac{nRT}{P} = \frac{8.3946 \times 8.315 \times 368.1}{105}$ (1)

$= \underline{245 L}$ (1)

2. A textile company uses a solution of sodium hypochlorite to bleach sheets. An industrial chemist is asked to investigate the change in concentration of the bleaching solution after sheets have been soaked in this solution for a time of 2 hours. The original solution is known to contain 30.0 g L^{-1} of calcium hypochlorite. During bleaching the hypochlorite ions are reduced to chloride ions.

The chemist takes 20.0 ml samples of the bleaching solution after 2 hours of soaking and titrates these samples with 0.250 mol L^{-1} sodium thiosulfate solution, using a starch-iodine indicator. The samples require 31.2 ml of thiosulfate solution for complete reaction. The titration reaction may be represented as follows:

$$OCl^-(aq) + 2S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S_4O_6^{2-}(aq) + Cl^-(aq) + H_2O(aq)$$

a) Calculate the original hypochlorite ion concentration in mol L^{-1} [3 marks]

b) Calculate the hypochlorite ion concentration after soaking in mol L^{-1} [3 marks]

c) What mass of calcium hypochlorite would need to be added to 100L of the solution after 2 hours of bleaching to restore the original hypochlorite ion concentration? [5 marks]

(a) $[Ca(OCl)_2] = 30.0 \text{ g } L^{-1}$

$[Ca(OCl)_2] = \frac{30}{142.98} \text{ mol } L^{-1} = 0.2098 \text{ mol } L^{-1}$ (2)

$[OCl^-] = 2 \times .2098 = \underline{0.420 \text{ mol } L^{-1}}$ (1)

(b) $n_{S_2O_3^{2-}} = 0.25 \times .0312 = .0078$ (1)

$n_{OCl^-} = \frac{1}{2} n_{S_2O_3^{2-}} = .0039$ (1)

$[OCl^-] = \frac{n}{V} = \frac{.0039}{.02} = 0.195 \text{ mol } L^{-1}$ (1)

2. cont.

(c) n_{OCl^-} in 100 L (originally) = .42 × 100 = 42 mols (1)

n_{OCl^-} after soaking = .195 × 100 = 19.5 (1)

n_{OCl^-} needed = 42 − 19.5 = 22.5 (1)

$n_{[Ca(OCl)_2]}$ required = $\frac{1}{2}$ n_{OCl^-}

= 11.25 mols (1)

$m_{Ca(OCl)_2}$ = 11.25 × 142.98

= 1.61 kg (1)

3. An ester underwent hydrolysis to produce a monoprotic carboxylic acid X and a secondary alcohol Y.

A 17.5 g sample of pure X, when combusted, produced 44.15 g of carbon dioxide and 7.750 g of water as the only products.

Y was oxidised with potassium dichromate according to the following equation:

$$3Y + Cr_2O_7^{2-} + 8H^+ \rightarrow 3Z + 2Cr^{3+} + 7H_2O$$

44.88 ml of 0.500 mol L^{-1} of potassium dichromate solution was required to oxidise 4.99 g of Y.

a) Calculate the empirical formula of X [5 marks]

b) Calculate the molar mass of Y [3 marks]

c) Draw possible structures of X and Y [2 marks]

d) Name the original ester. [1 marks]

a)

C

$n_{CO_2} = n_C = \frac{44.15}{44.01} = 1.00$ mol

$m_C = 12.01$ g

H

$n_{H_2O} = \frac{7.75}{18.016} = .430$

$n_H = 2 \times .430 = .860$

$m_H = .860 \times 1.008 = .867$ g

O

$m_O = (17.5) - (12.01 + .867) = 4.623$ g

$n_O = \frac{4.623}{16} = .289$

	C	H	O
mol	1	.867	.289
÷ .289	3.5	3	1
× 2	7	6	2

EF $C_7H_6O_2$

3. cont.

(b)

$n_{Cr_2O_7^{2-}} = c \times v = .5 \times .04488$

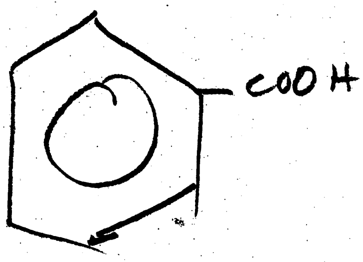
$= .02244$

$n_Y = \frac{3}{1} \times n_{Cr_2O_7^{2-}} = .06732$

$M_r(Y) = \frac{mass}{n} = \frac{4.99}{.06732}$

$= 74.1\ g\ mol^{-1}$

(c) X



Y

$CH_3 - CH(OH) - CH_2CH_3$

(d) 2 butyl benzoate

4. A hydrochloric acid solution contains 15% hydrogen chloride by mass. 10.20g sample of this solution was diluted to 100.0 ml in a volumetric flask. A 25.0 ml sample of this diluted acid solution was then added to 48.0 ml of 0.118 mol L^{-1} NaOH solution. Calculate the pH of the final solution.

[9 marks]

$m_{HCl} = 10.20 \times .15 = 1.53g$ (1)

$n_{HCl} = \frac{1.53}{36.458} = 0.0420$ mol (1)

$[HCl] = \frac{.0420}{.1} = .420$ mol L^{-1} (1)

$H^+ + OH^- \rightarrow H_2O$

$n_{HCl} = .420 \times .025$

$n_{H^+} = .0105$ (1)

$n_{NaOH} = n_{OH^-}$

$= .118 \times .048$ (1)

$n_{OH^-} = .005664$

$n_{H^+} > n_{OH^-}$ (1 : 1) OH^- is LR (1)

n_{H^+} in excess $= .0105 - .005664$ (1)

$= .004836$

$[H^+] = \frac{n}{V} = \frac{.004836}{.073} = 0.0662$ mol L^{-1} (1)

$pH = -\log_{10} .0662$

$= 1.18$ (1)

5. A 2.00g sample containing potassium oxalate ($K_2C_2O_4$), oxalic acid dihydrate ($H_2C_2O_4.2H_2O$) and impurities was dissolved in 100.0 ml of water and divided into two 50.0 ml portions.

One portion required 48.32 ml of 0.1010 mol L^{-1} NaOH to reach an end point using phenolphthalein as an indicator.

The other portion required 47.74 ml of 0.0255 mol L^{-1} $KMnO_4$ solution for complete reaction, according to the following equation:

$$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

Assuming that the impurities are inert, calculate the percentages of the potassium oxalate and oxalic acid dihydrate in the solid sample.

[11 marks]

Sample 1

$H_2C_2O_4 + 2OH^- \rightarrow C_2O_4^{2-} + 2H_2O$

$n_{OH^-} = .1010 \times .04832 = 4.88 \times 10^{-3}$ (1)

$n_{H_2C_2O_4} = \frac{1}{2} n(OH^-) = .00244$ (1)

$n_{H_2C_2O_4}$ in original sample $= \frac{100}{50} \times .00244$

$= .00488$ (1)

$m_{H_2C_2O_4} = .00488 \times 126.068$

$= 0.6152g$ (1)

$\% H_2C_2O_4 = \frac{.6152}{2} \times \frac{100}{1}$

$= 30.8\%$ (1)

5. cont.

Sample 2

$n_{MnO_4^-} = c \times V = .02555 \times .04774$

$= 1.122 \times 10^{-3}$ (1)

$n(C_2O_4^{2-}) = \frac{5}{2} \times n_{MnO_4^-}$

$= 3.043 \times 10^{-2}$ (1)

$n_{C_2O_4^{2-}}$ in original sample = $\frac{100}{50} \times 3.043 \times 10^{-2}$
(total)

$= .00609$ mol (1)

$n_{C_2O_4^{2-}}$ from $K_2C_2O_4 = n_{total} - n_{H_2C_2O_4}$

$= .00609 - 00488$

$= .00121$ mol (1)

$m_{K_2C_2O_4} = .00121 \times 166.22$

$= .201$ g (1)

$\% K_2C_2O_4 = \frac{.201}{2} \times \frac{100}{1}$

$= 10.0\%$ (1)

Part 4

There is no single correct solution to this question, as it could be responded to in a variety of ways.

In order to achieve high marks, responses would need to:

- be relevant to the topics referred to in the question
- make specific reference to the material/information presented
- provide equations where appropriate
- link evidence to theory
- contain no errors

Listed below are some points that could have been addressed.

Acids & Bases

- brief description of theory of acid-base behaviour, for example Bronsted-Lowry

- similarities of and differences between sulfuric acid and hexanedioic acid
  - both are diprotic
  - sulfuric acid is strong (with an explanation of this term), which ionises in water according to the following equations:

    $H_2SO_4 + H_2O \rightarrow HSO_4^- + H_3O^+$

    $HSO_4^- + H_2O \rightleftharpoons SO_4^{2-} + H_3O^+$

  - hexanedioic acid is weak (with an explanation of this term), which ionises in water according to the following equations:

    $HOOC(CH_2)_4COOH + H_2O \rightleftharpoons HOOC(CH_2)_4COO^- + H_3O^+$

    $HOOC(CH_2)_4COO^- + H_2O \rightleftharpoons {}^-OOC(CH_2)_4COO^- + H_3O^+$

  - in equimolar solutions of each, sulfuric acid would have a higher concentration of H_3O^+ (H^+), and therefore a lower pH, where $pH = -\log[H^+]$

- the cyanide ion (CN^-) is a basic anion, which reacts with water according to the following equation:

  $$CN^-_{(aq)} + H_2O_{(l)} \rightarrow HCN_{(aq)} + OH^-_{(aq)}$$

  therefore aqueous solutions of cyanide salts (eg KCN) would have pH >7.

Acids & Bases (cont.)

- the reaction between NaCN and sulfuric acid to produce $HCN_{(g)}$ according to the following equation:

$$NaCN_{(s)} + H_3O^+_{(aq)} \rightarrow Na^+_{(aq)} + HCN_{(g)} + H_2O_{(l)}$$

  - H_3O^+ is the proton donor (acid)
  - CN^- is the proton acceptor (base)
  - H_2O is the conjugate base of H_3O^+
  - HCN is the conjugate acid of CN^-
  - the production of HCN by this reaction allows one to infer that it is a weaker acid (poorer proton donor) that H_3O^+

Bonding

- the different nature of bonding in an ionic (eg NaCN) and a covalent molecular (eg HCN or any R-CN) cyano compound, with an appropriate electron dot diagram for each

- prediction and explanation of the properties of an ionic and covalent molecular cyano compound using an appropriate model of bonding

- statement of trend regarding the melting points of 1,4-dicyanobutane, 1,6-hexanediamine and hexanedioic acid
  (hexanedioic acid > 1,6-hexanediamine > 1,4-dicyanobutane)

- an explanation of this trend in terms of the type and strength of intermolecular forces present between molecules of each substance

- statement of trend regarding the solubility in water of 1,4-dicyanobutane, 1,6-hexanediamine and hexanedioic acid
  (hexanedioic acid > 1,6-hexanediamine > 1,4-dicyanobutane)

- an explanation of this trend in terms of the type and strength of intermolecular forces present between molecules of each substance and between each substance and water which allows for the formation of an aqueous solution

- predict and explain the properties (eg MP) of nylon

- when discussing intermolecular forces, a description and explanation of each type (diagrams would be a useful inclusion)

Redox

- brief description of oxidation and reduction

- the preparation of 1,4-dicyanobutane by the reduction, via electrolysis, of an aqueous solution of cyanoethene
  - in electrolysis an external power source drives a nonspontaneous reaction forward. Electrical energy is transformed into chemical potential energy
  - the reduction half-equation implies that the aqueous solution of cyanoethene must be acidified
  - the reduction of cyanoethene would occur at the cathode, which is the negative electrode in an electrolytic cell
  - the reduction of cyanoethene in these conditions is more likely than the reduction of water and $H^+_{(aq)}$

- the reaction between 1,4-dicyanobutane and hydrogen gas as a redox reaction according to the following equation:

$$NC\text{-}(CH_2)_4\text{-}CN \ + \ 4H_2 \ \rightarrow \ H_2N\text{-}(CH_2)_6\text{-}NH_2$$

  - hydrogen in the hydrogen gas is oxidised (change in oxidation state from 0 to +1)
  - carbon in the cyano group is reduced (change in oxidation state from +3 to -1)

- hexanedioic acid could be prepared by the oxidation of 1,6-hexanediol via reaction with an oxidant (oxidising agent), for example acidified potassium permanganate
  - 1,6-hexanediol would initially be oxidised to 1,6-hexanedial, according to the following equation:
    $HO\text{-}(CH_2)_6\text{-}OH \rightarrow OHC(CH_2)_4CHO + 2H^+ + 2e^-$
  - 1,6-hexanedial would then be oxidised to 1,6-hexanedioic acid, according to the following equation:
    $OHC(CH_2)_4CHO + H_2O \rightarrow HOOC(CH_2)_4COOH + 2H^+ + 2e^-$

Organic Chemistry

- write the full structural formula of organic compounds
- types of organic compounds (eg amines, carboxylic acids, polymers) – their properties and reactions
- reactions of organic compounds (eg oxidation, polymerisation)

Reactions

- acid-base – as described previously
- redox – as described previously
- polymerisation
  - condensation polymerisation – use example provided to show formation of nylon
  - addition polymerisation – provide an example and compare with condensation polymerisation
- reaction rates & catalysis