TRINITY COLLEGE

Chemistry 3A/3B - Semester 2, 2015

NAME : 12 CHEM SEM2 2015 (SOLUTIONS)

Please indicate your answer with a *cross* (X) within the box. If you make an error, circle the INCORRECT ANSWER.

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

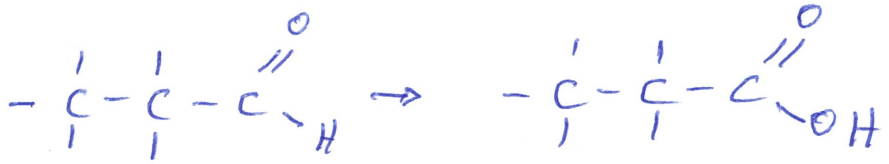
1. (a) $Mg_{(s)} + 2\,CH_3COOH_{(aq)} \rightarrow Mg(CH_3COO)_{2(aq)} + H_{2(g)}$ (1)

OBS: A silver (grey) metallic solid was added to a clear and colourless solution. There was mild effervescence and evolution of a colourless, odourless gas. The solid dissolved to leave a clear and colourless solution. (1)

[4]

* Must represent weak acid as a molecule
$-\frac{1}{2}$ for any error of phase but no more than that.

(b)



$C_3H_6O \rightarrow C_3H_6O_2$

$C_3H_6O + H_2O \rightarrow C_3H_6O_2$

$C_3H_6O + H_2O \rightarrow C_3H_6O_2 + 2H^+ + 2e^-$

$\Rightarrow 5\,(CH_3CH_2CHO + H_2O \rightarrow CH_3CH_2COOH + 2H^+ + 2e^-)$

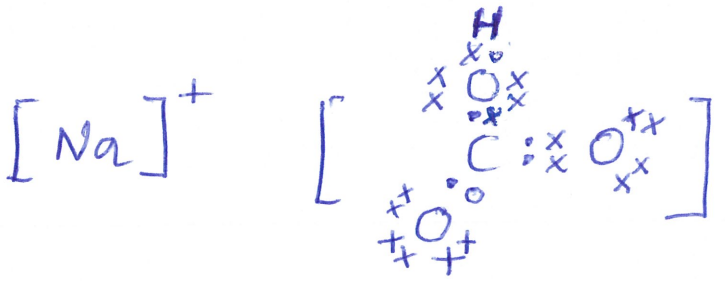
$2\,(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O)$

$5\,CH_3CH_2CHO + 2MnO_4^- + 5H_2O + 6H^+ \rightarrow 5CH_3CH_2COOH + 2Mn^{2+} + 8H_2O + 10H^+$ (1)

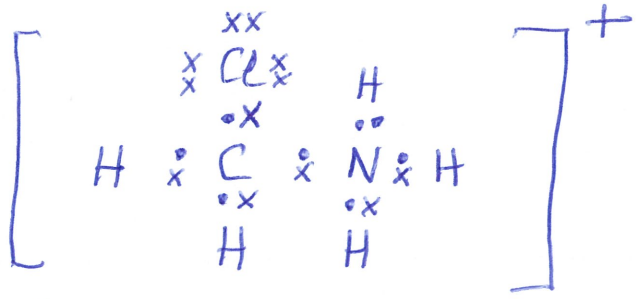
$\Rightarrow 5\,CH_3CH_2CHO_{(l)} + 2MnO_{4(aq)}^- + 6H^+_{(aq)} \rightarrow 5CH_3CH_2COOH_{(aq)} + 2Mn^{2+}_{(aq)} + 3H_2O_{(l)}$

OBS: A clear purple solution is added to a clear and colourless liquid. The purple solution decolourises to leave a clear pale pink solution. (Accept colourless!) (1)

* Must use Semi-Structure. * They do not have to show working!
* $-\frac{1}{2}$ for any error of phase.

2. (a)  (1)

[2]

(b)  (1)

[2] 3. CH_3F , CH_2F_2 , CHF_3 (2)

* 2 MARKS IF THEY GET ALL THREE + NO EXTRAS!

−1 FOR ANY EXTRA OR ANY LEFT OUT DOWN TO ZERO.

[4] 4. (a) $Zn \rightarrow Zn^{2+} + 2e^-$ (½)

(b) $2H^+ + 2e^- \rightarrow H_2$ (½)

(c) E.M.F = +0.76V (½)

(d) This is the STANDARD COUPLE. (½)

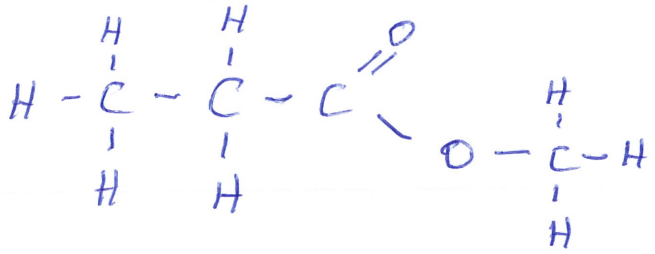
(e) ZINC. (½)

(f) Platinum is INERT. (½)

(g) $ZnCO_3(s)$ (½) / $CO_2(g)$ (½) * Pay $H_2O(l)$

3/

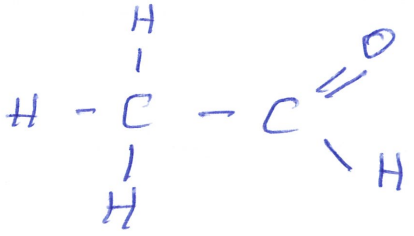
5. (a)



(½)

METHYL PROPANOATE (½)

(b)

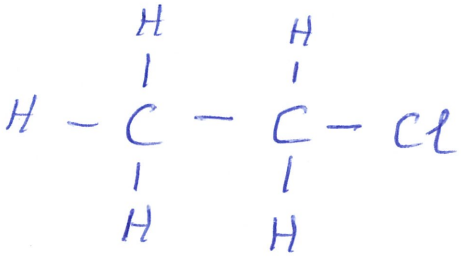


(½)

4

ETHANAL (½)

(c)

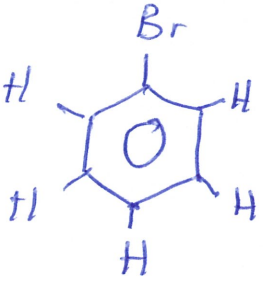


(½)

CHLORODETHANE or 1-CHLORODETHANE (½)

(d)

or



(½)

* ACCEPT EITHER VIEW

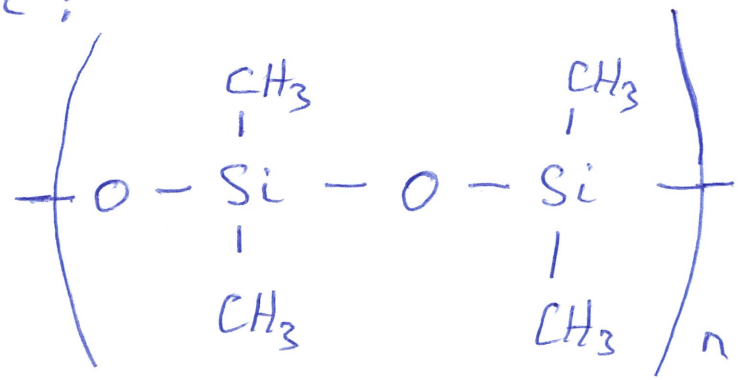
BROMOBENZENE (½)

* Take off ½ a mark for missed 'H' atoms up to no more than −1 for the question!

6. (a) The product is called a SILANOL as it has ALCOHOL functional groups linked to silicon instead of carbon. (1)

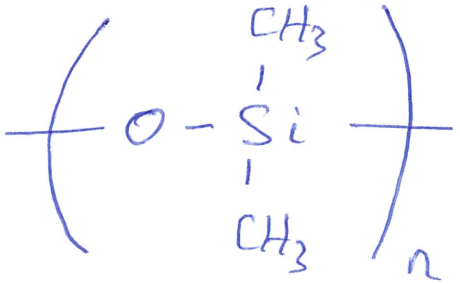
(b) DIMER:

[4]

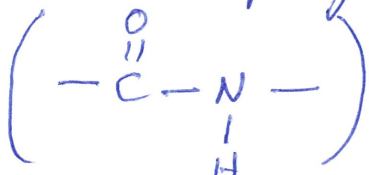


(1)

SMALLEST REPEATING UNIT:

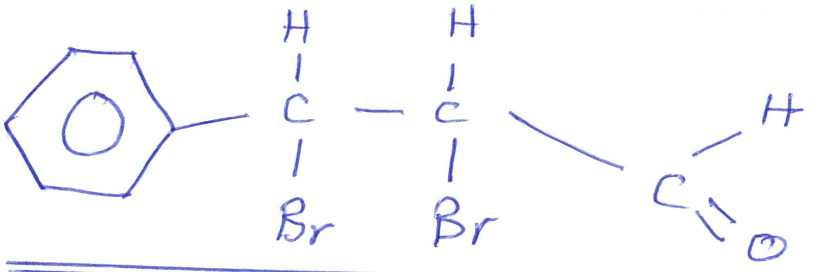


EITHER WILL DO!

(c) Nylon 6,6 is a polyamide with a key link  which means that there is potential for H-BONDING (1) interaction between one polymer chain and another as well as DISPERSION forces which give it a higher melting point making it solid. The silicone does not have this potential as well as the fact that its silicon-oxygen bond is LONGER than a carbon-carbon bond spreading electrons and weakening dispersion forces so it is LIQUID. (1)

7. (a) ALKENE (½) + ALDEHYDE (½)

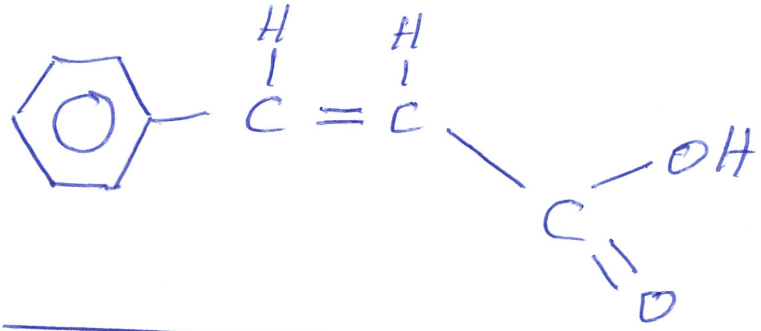
(b)



(1)

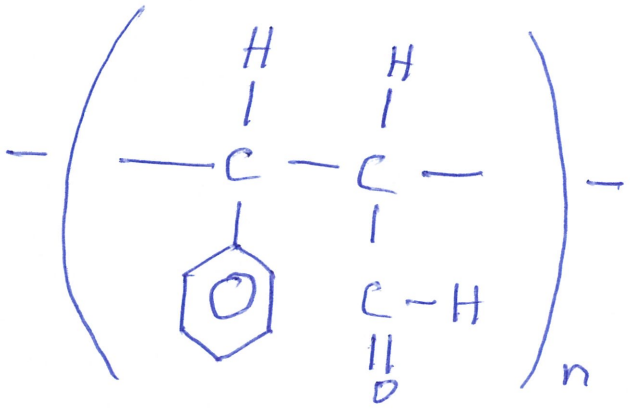
4

(c)



(1)

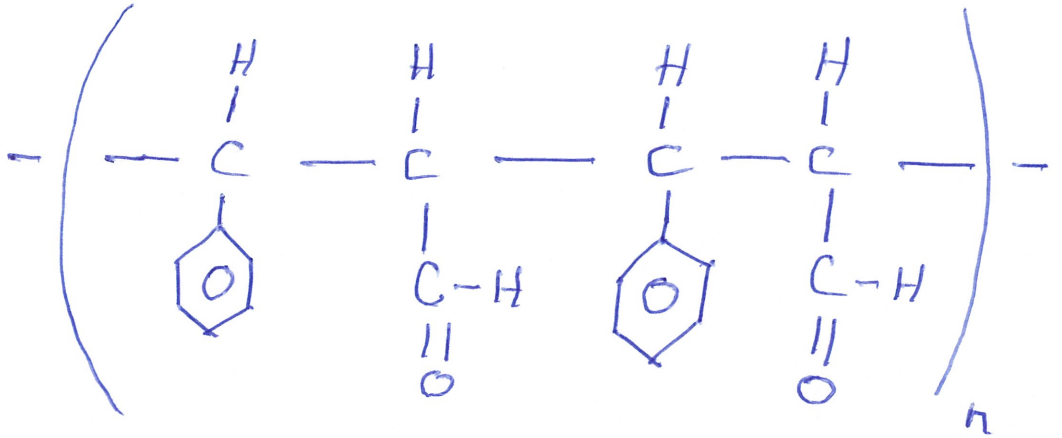
(d)



SMALLEST REPEATING UNIT.

(1)

OR



DIMER

8. The solution would turn YELLOW on addition of base. (1/2)

$$Cr_2O_7^{2-} + H_2O \rightleftharpoons 2CrO_4^{2-} + 2H^+$$

(1/2) $2H^+ + 2OH^- \rightarrow 2H_2O$

[2]

If base is added to this system at equilibrium it will have the effect of NEUTRALISING some of the acidity and LOWERING the $[H^+]$.

The system will ATTEMPT to MINIMISE THE EFFECT OF THE IMPOSED CHANGE and will SHIFT the position of equilibrium to the RIGHT.

This will lower $[Cr_2O_7^{2-}]$ which is orange and increase the $[CrO_4^{2-}]$ which is yellow, both changes will lead to the system being more yellow. (1)

9. (a) C = HF (1/2) OR NH_4Cl OR $NH_4^+ + H_2O \rightleftharpoons H_3O^+ + NH_3$ WEAK ACID: $HF + H_2O \rightleftharpoons H_3O^+ + F^-$ (1)

(b) F = KOH (1/2) STRONG BASE: $KOH \rightarrow K^+ + OH^-$ (1)

[4]

(c) HF / KF (1)

10.

(a) VOLUME INCREASED. (½)

(b) THE SYSTEM IS AT EQUILIBRIUM. (½)

(c) CHLORINE GAS WAS INJECTED. (½)

[4] (d) SYSTEM HEATED. (½)

(e) CURVES WOULD HAVE COME TO PLATEAUS MORE QUICKLY (LESS TIME). (½)

(f) If more PCl_5 was injected to the system at equilibrium the system will ATTEMPT TO MINIMISE THE EFFECT OF THE IMPOSED CHANGE. The system will (1) SHIFT to the LEFT to use up some of the extra PCl_5. The $[PCl_5]$ will be reduced from its adjusted value but GREATER than original. The $[PCl_3]$ and $[Cl_2]$ will (½) both be GREATER when a new equilibrium is established

11. (a) STRONG BASE v WEAK ACID (SB v WA) (½)

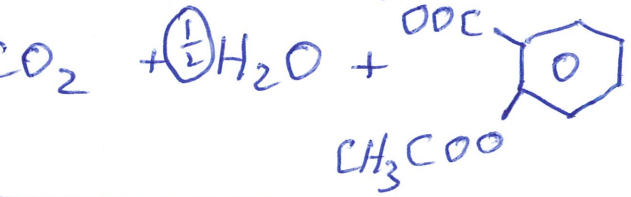
[1] (b) STRONG ACID v WEAK BASE (SA v WB) (½)

TOTAL /35

12 : 2 : 15 EXTENDED ANSWER

1. (a) CARBOXYLIC ACID (½) + ESTER (½)

(b) $C_9H_8O_4$ (1)

(c) (½) CO_2 + (½) H_2O +  (1)

(d) The molecular form is a large organic molecule and will be largely non-polar despite the polarity of the -OH groups of the acid and the carbonyl carbon (CO). (1)

This form will not be able to form a significant SOLUTE - SOLVENT interaction (1) with water to allow it to dissolve.

The ionic form once formed is able to (1) form a strong ION - DIPOLE attraction to water which will allow it to dissolve far more readily.

(e) $pH = 2.1$

$[H^+] = 10^{-pH}$

$= 10^{-2.1}$ (1)

$= 7.94 \times 10^{-3}\ M$

(f) The MOLECULAR or unionised form (1) of aspirin will be present in higher concentration. In the stomach there is a relatively high $[H^+]$. According to Le Chatelier's principle the presence of H^+ ions will (1) cause a SHIFT in the position of the equilibrium towards the RIGHT. The (1) system will be attempting to minimize the effect of the extra acid on the system and use some of it up.

(g) $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

(i) $NaHCO_3$

70% BY MASS

TABLET = 3.000g

TWO TABLETS = 2×3.000
$= 6.000\,g$

$\therefore m(NaHCO_3) = \frac{70}{100} \times 6.000$
$= \underline{4.200\,g}$ (1)

$NaHCO_3$

22.99
$+ 1.008$
$+ 12.01$
$+ 16.00 \times 3$
$84.008\ g\,mol^{-1}$

$n(NaHCO_3) = \frac{m}{M}$
$= \frac{4.200}{84.008}$
$= 0.04999$ (1)
$= \underline{0.0500\,mol}$

$$n(HCl) = n(NaHCO_3)$$

$$= \underline{0.0500 \text{ mol}} \quad (\tfrac{1}{2})$$

HCl

1.008

35.45

$36.458 \text{ g mol}^{-1}$

$$m(HCl) = n \times M \quad (\tfrac{1}{2})$$

$$= 0.0500 \times 36.458$$

$$= \underline{1.82 \text{ g}}$$

(ii) $$[H^+] = \frac{n}{V}$$

$$= \frac{0.0500}{0.03500}$$

$$= \underline{1.4286 \text{ M}} \quad (\tfrac{1}{2})$$

$$pH = -\log_{10}[H^+]$$

$$= -\log_{10} 1.4286$$

$$= \underline{-0.155} \quad (\tfrac{1}{2})$$

2. (a) $m(N) = 6.922 \times \frac{13.59}{100}$

$= 0.94069$

$= \underline{0.941\ g}$ (½)

(b) CO_2

12.01

16.00 x2

44.01 $g\,mol^{-1}$

$n(CO_2) = \frac{m}{M}$

$= \frac{11.83}{44.01}$ (½)

$= \underline{0.2688\ mol}$

11

$n(C) = n(CO_2)$

$= \underline{0.2688\ mol}$ (½)

H_2O

1.008 x2

16.00

18.016 $g\,mol^{-1}$

$n(H_2O) = \frac{m}{M}$

$= \frac{5.442}{18.016}$ (½)

$= \underline{0.3020}\ mol$

$n(H) = 2 \times n(H_2O)$

$= 2 \times 0.3029$ (½)

$= \underline{0.604\ mol}$

$m(C) = n \times M$

$= 0.2688 \times 12.01$

$= \underline{3.228\ g}$ (½)

$m(H) = n \times M$

$= 0.604 \times 1.008$

$= \underline{0.6089\ g}$ (½)

(½) $m(N) = \underline{0.941\ g}$ * FROM PART (a)

$n(N) = m/M = \frac{0.941}{14.01} = \underline{0.06717\ mol}$

$m(O)_{\text{COMPOUND}} = \text{TOTAL} - m(C+H+N)$

$= 6.922 - (3.228 + 0.6089 + 0.941)$

$= 6.922 - (4.777)$

$= \underline{2.145\ g}$ (1/2)

$n(O) = \frac{m}{M}$

$= \frac{2.145}{16}$ (1/2)

$= \underline{0.134\ mol}$

C	:	H	:	O	:	N
$\frac{0.2688}{0.06717}$	:	$\frac{0.6019}{0.06717}$	:	$\frac{0.134}{0.06717}$	:	$\frac{0.06717}{0.06717}$
4.00	:	8.96	:	2.00	:	1.00

$\therefore$ EF $= \underline{C_4H_9O_2N}$ (1/2)

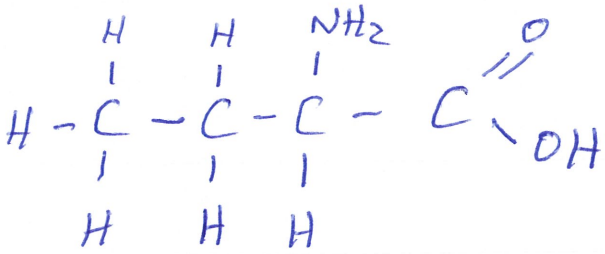
(c) E.F.W $= 4(12.01) + 9(1.008) + 2(16.00) + (14.01)$

$= \underline{103.1\ g}$.

$\therefore$ M.F.W $= 103.112\ g\,mol^{-1}$ (1)

$\therefore$ MF = EF $= \underline{C_4H_9O_2N}$

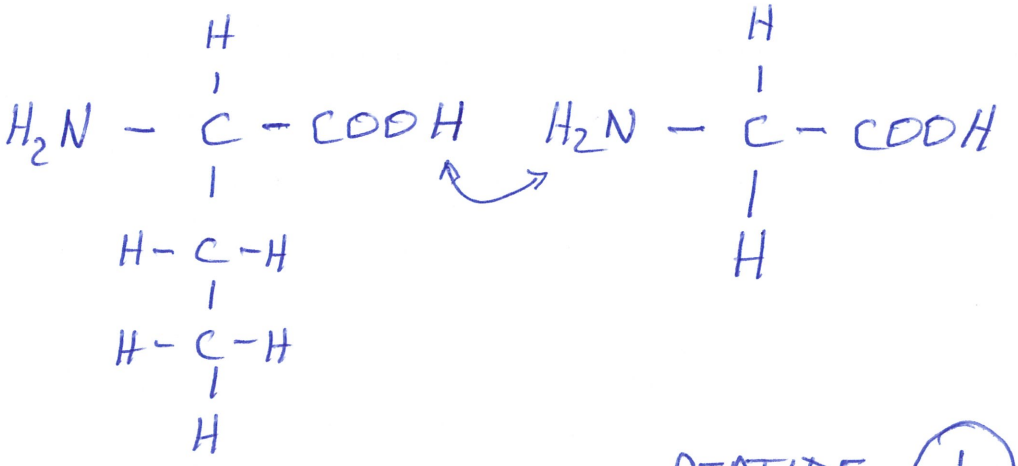
(d)



(1)

2 - AMINOBUTANOIC ACID (1)

(e)



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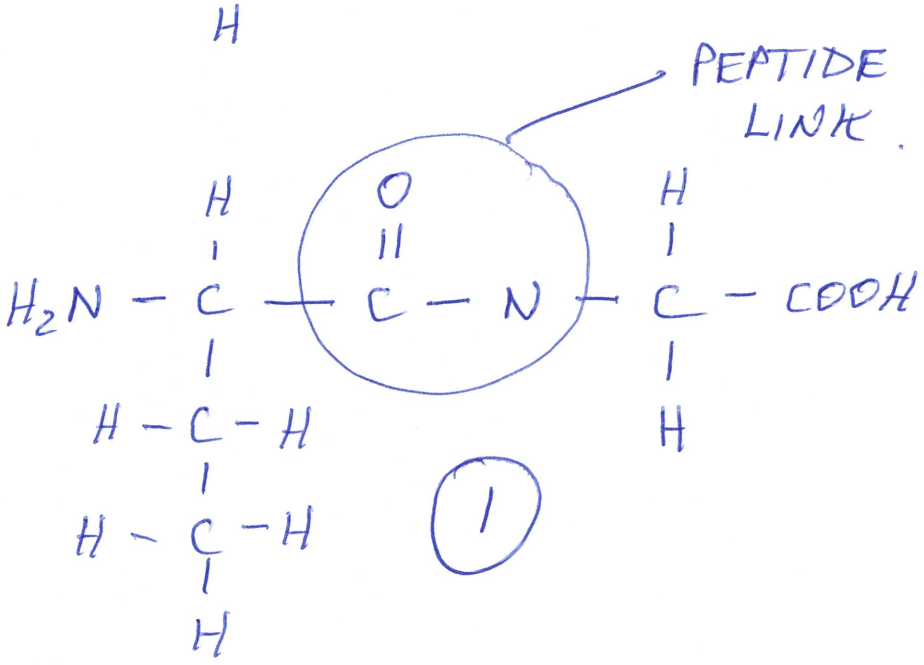
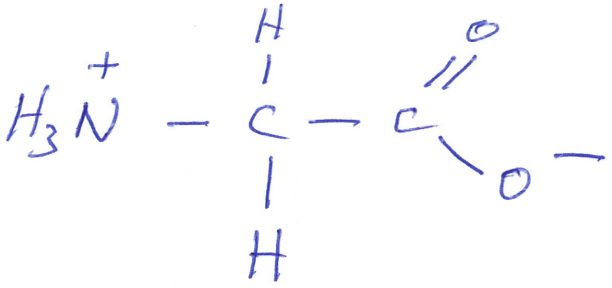


(1/2)

(1)

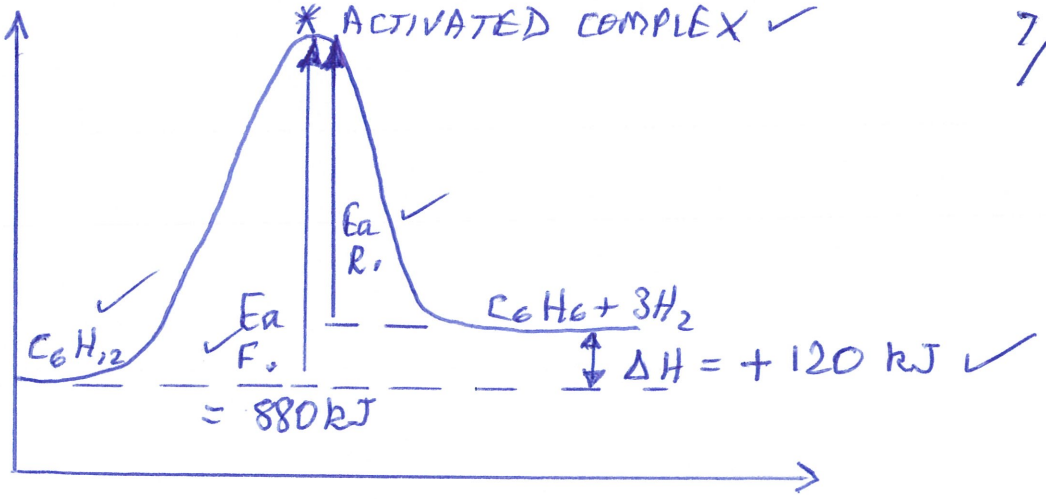
(f)



(1)

ZWITTERION OF GLYCINE

3. (a) 7/



$6 \times (\frac{1}{2}) = (3)$

10

* SUBTRACT MARKS FOR LACK OF NEATNESS OR WRONG SHAPE + SCALE.

(b) $K = \dfrac{[C_6H_6][H_2]^3}{[C_6H_{12}]}$ (1/2)

(c) HIGH TEMPERATURE (1/2) + HIGH PRESSURE (1/2)

(d) Liquefaction of benzene prevents it returning to the 'Reaction Tower' removing it from the equilibrium causing a SHIFT in position to the RIGHT and INCREASING YIELD (1)

(e) HIGH YIELD + RATE IS DESIRED ⇒ PROFITABILITY

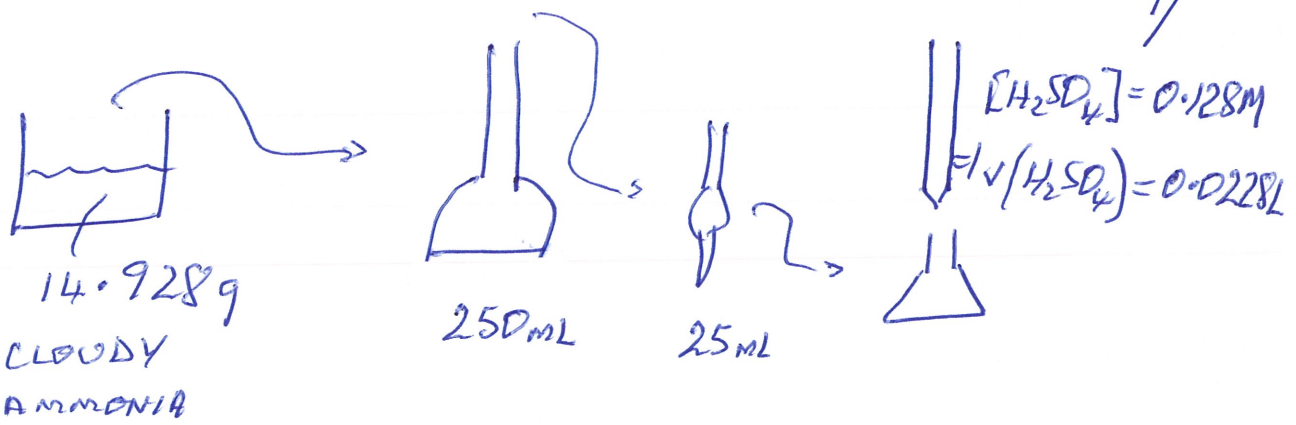
(1) HIGH TEMPERATURE: * High temperature will cause the equilibrium to SHIFT to the RIGHT increasing yield. Le Chatelier predicts this as the system will ATTEMPT TO MINIMISE the effect of the imposed change and use up some of the extra heat. (2)

* HIGH TEMPERATURE will also increase the rate of all reactions and hence the RATE OF ATTAINMENT OF EQUILIBRIUM.

(2) COMPROMISE PRESSURE:

High pressure will increase the rate of all reactions and hence the RATE OF ATTAINMENT of equilibrium. If the pressure is too high Le Chatelier predicts that the system will SHIFT to the LEFT, the side with least gas molecules, as it attempts to MINIMISE THE EFFECT OF THE IMPOSED CHANGE. This would reduce yield and profitability so a compromise balancing the demands of rate and yield is required. (2)

4.



$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

$n(H_2SO_4) = C \times V$

$= 0.128 \times 0.0228$

$= \underline{0.0029184 \text{ mol}}$ (1)

4

$n(NH_3)_{25mL} = 2 \times n(H_2SO_4)$

$= 2 \times 0.0029184$

$= \underline{0.005837 \text{ mol}}$ (1)

$n(NH_3)_{250mL} = \frac{250}{25} \times n(NH_3)_{25mL}$

$= \frac{250}{25} \times 0.005837$ (1)

$= \underline{0.05837 \text{ mol}}$

NH_3

1.008×3

14.01

$17.034 \text{ g mol}^{-1}$

$m(NH_3) = n \times M$

$= 0.05837 \times 17.034$

$= \underline{0.9943 \text{ g}}$ ($\frac{1}{2}$)

$\therefore$ % MASS $NH_3 = \frac{0.9943}{14.928} \times 100$

$= \underline{6.66\%}$ ($\frac{1}{2}$)