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CHEMISTRY
Unit 4
Trial Examination

SOLUTIONS BOOK

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Use this page as an overlay for marking the multiple choice answer sheets. Simply photocopy the page onto an overhead projector sheet. The correct answers are open boxes below. Students should have shaded their answers. Therefore, any open box with shading inside it is correct and scores 1 mark.

	ONE ANSWER PER LINE					ONE ANSWER PER LINE			
1	■	■	☐	■	11	■	■	■	☐
2	■	■	■	☐	12	☐	■	■	■
3	☐	■	■	■	13	■	☐	■	■
4	■	■	☐	■	14	☐	■	■	■
5	■	☐	■	■	15	■	■	☐	■
6	■	☐	■	■	16	■	■	■	☐
7	■	■	☐	■	17	☐	■	■	■
8	☐	■	■	■	18	■	☐	■	■
9	☐	■	■	■	19	☐	■	■	■
10	■	■	■	☐	20	■	■	■	☐

SECTION A (Total 20 marks)

1.	C	**2.**	D	**3.**	A	**4.**	C	**5.**	B
6.	B	**7.**	C	**8.**	A	**9.**	A	**10.**	D
11.	D	**12.**	A	**13.**	B	**14.**	A	**15.**	C
16.	D	**17.**	A	**18.**	B	**19.**	A	**20.**	D

Comments for Section A answers

Question 1
Increasing temperature increases the frequency of collisions but does not change the activation energy. However, a greater percentage of molecules will have the required activation energy. A catalyst provides a lower energy pathway i.e. it reduces the activation energy.
Correct answer: C

Question 2
Smaller pieces would increase the rate so line 2 is appropriate as the mass decrease is faster.
More concentrated acid would increase the rate so line 2 is appropriate as the mass decrease is faster but the two graphs should plateau at the same mass loss.
A lower T decreases the rate so line 2 is inappropriate as the mass decrease is faster.
Correct answer: D

Question 3
A will have more moles but the same concentration. No change.
B has a higher concentration – increase rate.
C has the same concentration but higher temperature – increase rate
D has a higher concentration – increase rate.
Correct answer: A

Question 4
A catalyst lowers the activation energy and this will result in I being lower. This will also result in a reduction of energy released when bonds are formed (II). **Correct answer: C**

Question 5

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]}$$

A. CF = 0.20 x 0.30 / 0.15 = 0.40
B. CF = 0.15 x 0.15 / 0.20 = 0.11
C. CF = 0.10 x 0.40 / 0.10 = 0.40
D. CF = 0.80 x 0.15 / 0.30 = 0.40 **Correct Answer: B**

Question 6
Mass is conserved in a chemical reaction. **Correct Answer: B**

Question 7
The second equation is the reverse of the first equation with half-the coefficients.
Therefore $K_1 = (1/K)^{½} = 250\ M^{-½}$ **Correct Answer: C**

Question 8
Ammonia is a base so any dilution will lower the pH.
The ionisation is $NH_3 \rightarrow NH_4^+ + OH^-$
The dilution causes the system to partially offset the disturbance by producing more particles effecting a net forward reaction. **The number of moles of both $NH_4^+ + OH^-$ has increased** and therefore % ionisation increases. **Correct Answer: A**
(Note though, that the overall concentration of NH_4^+ and OH^- will have decreased because of the dilution.)

Question 9
The reaction is: $CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$
Adding the base will neutralise some of the acid and pH will increase. Not I.
Propanoic acid is a weak acid. It ionises to form $CH_3CH_2COO^-$. Not III. By default II only.
Check:
$n(NaOH) = c \times V = 0.080 \times 100 \times 10^{-3} = 8.0 \times 10^{-3}$
$n(CH_3CH_2COOH) = c \times V = 0.16 \times 100 \times 10^{-3} = 16 \times 10^{-3}$
$n(CH_3CH_2COOH)_{remaining} = 8.0 \times 10^{-3}$ $n(CH_3CH_2COO^-)_{produced} = 8.0 \times 10^{-3}$
Must be II only. **Correct answer: A**

Question 10
$nBa(OH)_2 = c \times V = 0.010 \times 100.0 \times 10^{-3} = 1.00 \times 10^{-3}$ mol $Ba(OH)_2 \rightarrow 2\,OH^-$
$n(OH^-) = 2.00 \times 10^{-3}$ mol $V_{new} = 1.00$ L
$[OH^-] = 2.00 \times 10^{-3} / 1 = 0.00200$ M
$pOH = -\log_{10}[OH^-] = 2.7$ $pH = 14 - pOH = 11.3$ **Correct Answer: D**

Question 11
A, B, C are endothermic. **Correct Answer: D.** In addition Na^+ is more stable than Na so energy has been released i.e. the reaction is exothermic.

Question 12
$E = mC\Delta T = 50.0 \times 0.0840 \times 10.0 = 42$ J **Correct Answer: A**

Question 13
$CH_3CH_2OH + 3\,O_2 \rightarrow 2CO_2 + 3H_2O$
From the data book $\Delta H = 1364$ kJ / 2 mol of CO_2
$= 1364 / 4$ for 0.500 mol $CO_2 = 341$ kJ **Correct answer: B**

Question 14
From the Electrochemical series the following order is obtained.

$Cl_2(g)/Cl^-(aq)$

$Fe^{3+}(aq)/$**$Fe^{2+}(aq)$**

$I_2(s)/I^-(aq)$

$Cu^{2+}(aq)/Cu(s)$

$Fe^{2+}(aq)/Fe(s)$

$Zn^{2+}(aq)/Zn(s)$

The strongest oxidant is Cl_2 and the strongest reductant is Zn. Spontaneous reaction is expected when the oxidant is higher than the reductant.
$Fe^{2+}(aq)$ as a reductant is bolded. It can only react with Cl_2. **Correct Answer: A**

Question 15
From the order in the Electrochemical series:
H^+ / H_2
Ni^{2+} / Ni
The strongest oxidant is H^+ and the strongest reductant is Ni. Spontaneous reaction is expected.
Ni will react with H^+.
Concentration Ni^{2+} would increase. Not A.
Reduction occurs at the cathode which is part of the half cell H^+ / H_2 not Ni^{2+} / Ni. Not B.
H^+ is being used up so pH would increase. **Correct Answer: C**
H^+ is being used up and H_2 is being produced at the anode. Not D.

Question 16
From the order in the Electrochemical series:
H_2O / H_2, OH^-
Mg^{2+} / Mg
The strongest oxidant is H_2O and the strongest reductant is Mg. Spontaneous reaction is with Mg reacting with H_2O to produce Mg^{2+}, H_2 and OH^-.
Correct Answer: D

Question 17
From the order in the Electrochemical series:
Sn^{4+} / Sn^{2+}
Zn^{2+} / Zn
The strongest oxidant is Sn^{4+} and the strongest reductant is Zn. Spontaneous reaction is with Zn reacting with Sn^{4+} to produce Zn^{2+} and Sn^{2+}. Zn releases electrons and is the anode which is assigned the negative polarity in a galvanic cell.
Correct Answer: A

Question 18
The cations (K^+) in the salt bridge move towards the cathode (-) half cell to counteract the loss of positive charge as Sn^{4+} ions are converted into Sn^{2+}. **Correct Answer: B.**

Question 19
Ag_2O/Ag + 0.34 V contains the cathode (+)
$Zn(OH)_2$ / Zn E^o contains the anode (-)
$E_{cell} = E^o(+) - E^o(-)$ $1.50 = 0.34 - E^o(-)$ $E^o(-) = 0.34 - 1.50 = -1.16$ V
Correct answer: A

Question 20
$n(Co^{3+}) = 1.00$ mol
$n(e^-) = 3 \times n(Co) = 3 \times 1.00 = 3.00$ mol
Need 3.00 F. **Correct answer: D**

SECTION B – Short answer questions

Question 1 (5 marks)

a. Activation energy is the minimum amount of energy needed to break bonds and initiate the reaction. **1 mark**

b. The curve should be to the right and have an average E_K lower than the curve shown. E_A should be in the same place. **1 mark**

c. The two areas must be equal. The number of molecules has not changed. **1 mark**

d. A greater proportion of molecules have sufficient energy to overcome the E_A. **1 mark**
Because more molecules are moving faster, there are more frequent collisions. **1 mark**

Question 2 (5 marks)

a. $CH_3CH_2CH_2COOH(l) + H_2O(l) \rightarrow CH_3CH_2CH_2COO^-(aq) + H_3O^+(aq)$ **1 mark**

b. $K_a = \dfrac{[CH_3CH_2CH_2COO^-][H_3O^+]}{[CH_3CH_2CH_2COOH]}$ **1 mark**

c. pH = 2.9 $[H^+] = 10^{-2.9}$ **1 mark**
$[H^+] = [CH_3CH_2CH_2COO^-]$ **1 mark**
Assuming the % ionisation is negligible compared with the concentration of the butanoic acid.
$K_a = \dfrac{(10^{-2.9})^2}{0.10}$ $K_a = 1.6 \times 10^{-5}$ **1 mark**

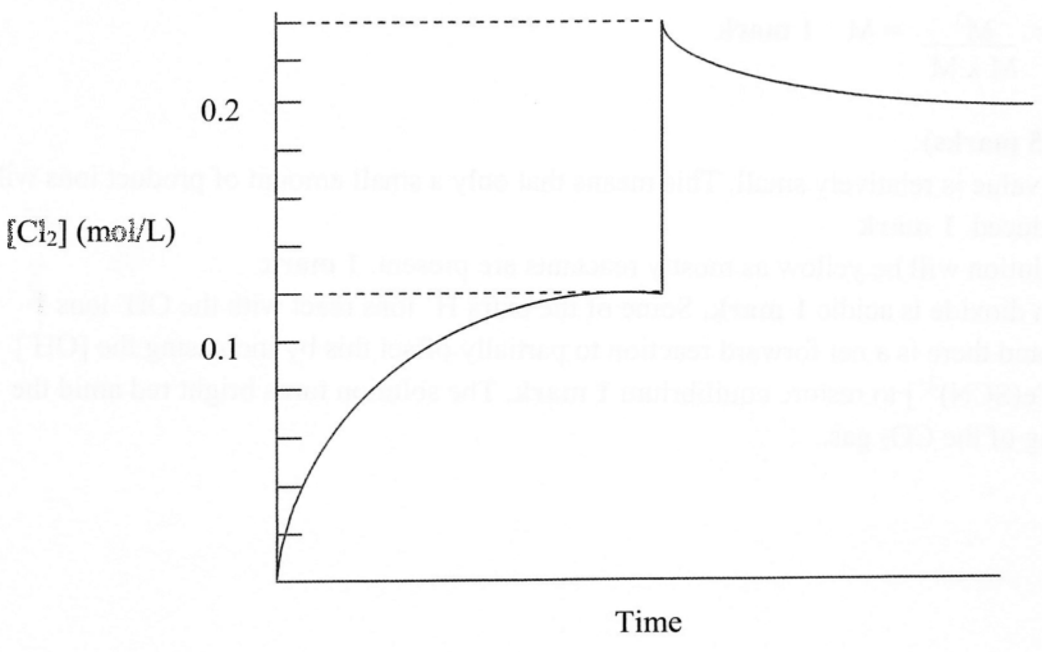
Question 3 (7 marks)

a. Equilibrium reactions reach a point where r_f is equal to r_b **1 mark**. Not all the reactants are converted at any point in time. **1 mark**

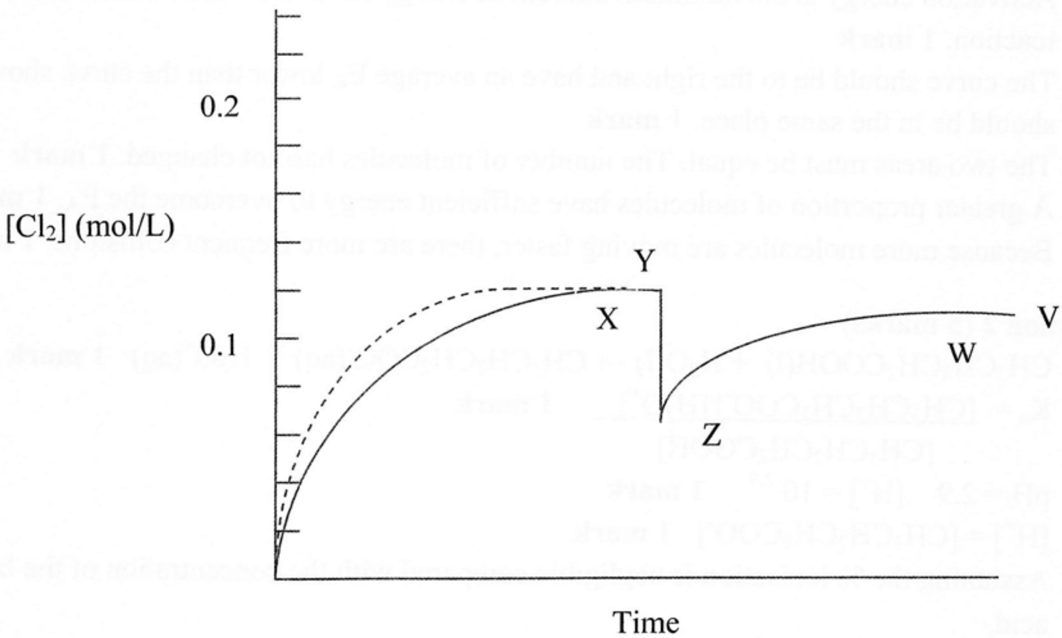
b. The volume of the syringe was increased by pulling the plunger outwards. **1 mark**

c. As the V increased, the overall concentration of each species decreased and the equilibrium position is disturbed **1 mark**. The system tries to partially offset the disturbance by a net movement to the side creating more particles and so there is a net forward reaction. **1 mark**

d. See graph below. A carefully drawn graph should go to $[Cl_2]$ = 0.24 M. **1 mark**



e. The curve rises faster but reaches equilibrium faster but to the same level where $[Cl_2] = 0.12$ M as shown. **1 mark**



Question 4 (4 marks)

Correct calculation of equilibrium concentrations **1 mark total for all 3 correct**

[A] = n/V = 4.0 / 2.0 = 2.0 M   [B] = n/V = 1.0 / 2.0 = 0.50 M   [C] = n/V = 3.0 / 2.0 = 1.5 M

$K_c = \frac{[C]^3}{[A][B]}$ **1 mark**

$K_c = \frac{[1.5]^3}{[2.0][0.50]}$

$K_c =$ 3.4 (2sf) **1 mark**

Units: $K_c = \frac{M^3}{M \times M} = M$ **1 mark**

Question 5 (5 marks)

a. The K value is relatively small. This means that only a small amount of product ions will be produced. **1 mark**

b. The solution will be yellow as mostly reactants are present. **1 mark**

c. Carbon dioxide is acidic **1 mark**. Some of the extra H^+ ions react with the OH^- ions **1 mark** and there is a net forward reaction to partially offset this by increasing the $[OH^-]$ and $[Fe(SCN)^{2+}]$ to restore equilibrium **1 mark**. The solution turns bright red amid the frothing of the CO_2 gas.

Question 6 (6 marks)
n(HCl) = c x V = 0.862 x 0.0600 = 0. 0517 mol
$nBa(OH)_2$ = c x V = 0.431 x 0.0400 = 0. 0172 mol **1 mark total for both correct calculations**

$$2HCl(aq) + Ba(OH)_{2\,(aq)} \rightarrow BaCl_2(aq) + 2H_2O(l)$$

$\mathbf{n_i}$	0.0517	0.0172
$\mathbf{n_r}$	0. 0344	0.0172

As shown above, the HCl is in excess **1 mark** → Must have some consideration of excess to obtain this mark.

$n(OH^-)$ = 2 x 0.0172 = 0.0.0344 mol **1 mark**

Heat released = ΔH x n = 56.2 x 0.0344 = 1.93 kJ = 1.93 x 10^3 J **1 mark**

E = CF x ΔT → ΔT = E / CF = 1.93 x 10^3 / 453 = 4.26 °C **1 mark**

Final temperature = 20.5 + 4.3 °C = 24.8 °C **1 mark**

Question 7 (7 marks) Allow marks for other sensible answers

a. **i. Advantage: any one of the following for 1 mark**
- quick
- relatively low cost way of obtaining heat
- portable

Disadvantage: any one of the following for 1 mark
- smoke is polluting
- smoke is smelly
- wood must be dry
- non- renewable in the short term

ii. Advantage: any one of the following for 1 mark
- much cleaner fuel
- can be controlled more easily
- more readily transported
- renewable

Disadvantage: 1 mark
- cost of conversion to ethanol

b. From the data booklet: $\Delta H_{ethanol}$ = −1364 kJ/ mol $M(CH_3CH_2OH)$ = 46.0 g mol^{-1}

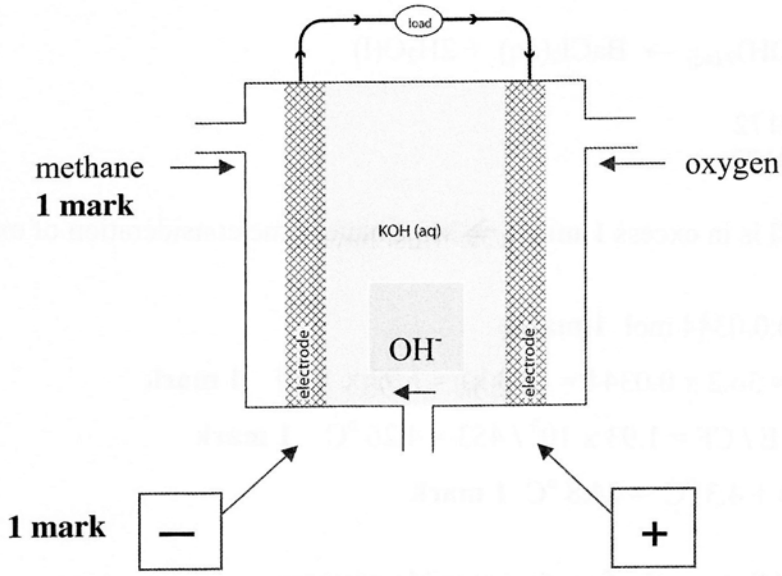
d = m/V → m = d x V m(ethanol) = 0.79 x 1000 = 790 g **1 mark**

using ratio of energy / mass

$$\frac{1364}{46.0} = \frac{E}{790}$$ **1 mark** E = 23.4 x 10^3 kJ **1 mark**

Question 8 (9 marks)

a, b



c. It is called a fuel cell because it has a continuous supply of reactants to produce constant production of electrical energy. **1 mark**

d. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ **1 mark**

e. There is no net change in the n(OH^-) **1 mark** as **per mole** of CH_4, although 8 mol of OH^- ions would be consumed, these are balanced by the production of 8 mol of OH^- ions by the reduction of $2O_2 + 4H_2O$ at the cathode **1 mark**.

f. The electrodes need to be: porous, catalytic, low cost, not able to be poisoned.
Any two of the above for 1 mark each → **2 marks**

g. OH^- ions move from cathode (-) to anode (+). See diagram above. **1 mark**

Question 9 (7 marks)

a. $Q = It = 1.00 \times 70.0 \times 60 = 4.20 \times 10^3$ C **1 mark**

$N(e) = 4.20 \times 10^3 / 1.60 \times 10^{-19} = 2.63 \times 10^{22}$ **1 mark**

$n(Cu) = m/M = 1.34 / 63.6 = 0.0211$ mol **1 mark** $n(e) = 2 \times n(Cu)$ **1 mark**

$\frac{2.63 \times 10^{22}}{2 \times 0.0211} = \frac{x}{1}$ $x = 6.23 \times 10^{23}$ **1 mark**

b. The value is greater. **1 mark**
The electrode has not been properly rinsed and some of the copper salt from solution remains or the electrode has not been fully dried or any other sensible suggestion that would cause a larger value. **1 mark**

Question 10 (7 marks)

Ammonia

a. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ **1 mark (must be balanced and correct states)**

ΔH = negative **1 mark**

b. Unreacted N_2, H_2 **1 mark**

c. Toxic gas, Corrosive **2 marks**

d. producing fertiliser **1 mark**

eg $H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$ **1 mark**

Ethene

a. eg $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$ **1 mark (must be balanced and correct states)**

ΔH = negative **1 mark**

b. Unreacted C_2H_6, C_2H_2 **1 mark**

c. Toxic gas, Flammable gas **2 marks**

d. producing polyethene **1 mark**

$n\,C_2H_4 \rightarrow —(CH_2CH_2)_n—$ **1 mark**

Nitric Acid

a. $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ **1 mark (must be balanced and correct states)**

ΔH = negative **1 mark**

b. Unreacted NO, NO_2 **1 mark**

c. Toxic gas, Corrosive **2 marks**

d. producing fertiliser **1 mark**

eg. $HNO_3 + NH_3 \rightarrow NH_4NO_3$ **1 mark**

Sulfuric Acid

a. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ **1 mark (must be balanced and correct states)**

ΔH = negative **1 mark**

b. Unreacted SO_2 **1 mark**

c. Corrosive, Oxidising Agent **2 marks**

d. producing fertiliser **1 mark**

eg. $H_2SO_4 + 2\,NH_3 \rightarrow (NH_4)_2SO_4$ **1 mark**

END OF SUGGESTED SOLUTIONS