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CHEMISTRY
Unit 4
Trial Examination

SOLUTIONS BOOK

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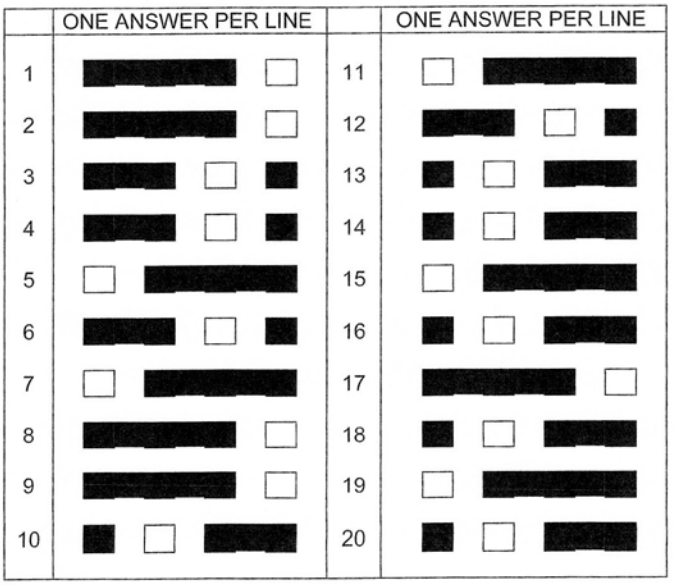
Use this page as an overlay for marking the multiple choice answer sheets. Simply photocopy the page onto an overhead projector sheet. The correct answers are open boxes below. Students should have shaded their answers. Therefore, any open box with shading inside it is correct and scores 1 mark.



SECTION A (Total 20 marks)

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

Comments for Section A answers

Question 1
Catalysts bind with reactant particles, therefore weakening bonds in the reactant particles and therefore lowering activation energy. **Correct answer is D** .

Question 2
Twice the volume of acid at the same concentration does not increase the number of particles per unit volume of acid. Hence this will not affect the rate of reaction. **Correct answer is D.**

Question 3
Don't forget to change amounts to concentrations before applying the equilibrium law.
$K = [C_2H_6] / [C_2H_4][H_2] = 2.50 \times 10^{-1} / (15.0 \times 10^{-2} \times 16.7 \times 10^{-2}) = 9.98\ M^{-1}$ **Correct answer is C.**

Question 4
Temperature is the only one of the changes that changes the value of the concentration fraction permanently. **Correct answer is C.**

Question 5
Higher pressure would cause a net forward reaction to try to reduce the increase in pressure. When the system returns to equilibrium, it has the same K value but with a greater amount of SO_3 in the mixture. Increasing pressure also increases the rate of reaction as there are more collisions per unit time.
Correct answer is A.

Question 6
On dilution, the ammonia solution becomes less basic, therefore **pH decreases** towards 7. However more ionisation occurs in an attempt to partially counteract the dilution. Hence **% ionisation increases**, even though overall concentration of all reactants decreases due to the dilution. **Correct answer is C.**

Question 7
The dilution of the strong base drops the pH by a factor of 100 in this case which is 2 pH units lower.
Correct answer is A.

Question 8
D represents the energy released when new bonds are formed. **Correct answer is D.**

Question 9
Using ratio, 98.7 kJ from 5.0 /31.0 mol therefore 2 mol of P releases $(2 \times 31 \times 98.7 / 5) = 1.22 \times 10^3$ kJ.
Correct answer is D.

Question 10
Because the process lowers the temperature of the surroundings, it must be endothermic and therefore has a positive ΔH. **Correct answer is B.**

Question 11
$n(HCl) = c \times V = 2.0 \times 300 \times 10^{-3} = 0.60$ mol ; $n(NaOH) = c \times V = 2.0 \times 200 \times 10^{-3} = 0.40$ mol
therefore HCl is in excess.
Energy released = 0.40 x 56 = 22.4 kJ
For resulting 500 mL of solution, for a 1°C increase, need 4.18 x 500 J = 2.09 kJ
22.4 kJ / 2.09 kJ = 10.7 °C. New temperature would be 30.7 °C. Closest temperature is 30 °C
Correct answer is A.

Question 12
The equation is reversed and the co-efficients halved. The $\Delta H = ½ (+110kJ) = +55$ kJmol^{-1}
Correct answer is C.

Question 13
In this combination, Ni (the strongest reductant) is oxidised to $Ni^{2+}$and H^+ ions (the strongest oxidant) are reduced. $[Ni^{2+}]$ increases, pH increases as H^+ is used up. The H^+ ions are reduced at the platinum electrode which is part of the standard hydrogen half-cell. **Correct answer is B.**

Question 14
Reduction occurs at the cathode and therefore only B and D are reductions. Given that the electrolyte is alkaline, B must be the one. **Correct answer is B.**

Question 15
According to the logic of the previous answer, OH^- is produced so pH must increase at the cathode.
Correct answer is A.

Question 16
At the anode, oxidation must be occurring. The strongest reductant present to be oxidised under these dilute conditions would be Fe^{2+} and the reaction is $Fe^{2+} \rightarrow Fe^{3+} + e^-$
Correct answer is B.

Question 17
Water is a stronger oxidant than K^+ (aq) and will be reduced at the cathode. Water will also be oxidised at the anode as there are no other reductants present. **Correct answer is D.**

Question 18
B and D are possible responses, but D does not take into account that ions may have different charges. So charge balance is the key. **Correct answer is B.**

Question 19
K^+ cannot be plated from aqueous solution. Cu^{2+} is the strongest oxidant and will deposit at the cathode first. If enough potential is applied, Ni^{2+} will also plate out. **Correct answer is A.**

Question 20
At the anode, oxidation of water occurs to produce O_2 gas via $2H_2O\ (l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$
H_2 gas could also be produced but only at the cathode by reduction of water. **Correct answer is B.**

SECTION B – Short answer questions

Question 1 (6 marks)

a. **i.** % ionisation = $\frac{[H^+]}{[HX]} \times \frac{100}{1}$ (can also use $\frac{[X^-]}{[HX]}$) **1 mark**

ii. $3.5 = \frac{[H^+] \times 100}{5.00 \times 10^{-3} / 0.100}$

$[H^+] = 1.75 \times 10^{-3}$ **1 mark** $\quad pH = -\log_{10} 1.75 \times 10^{-3} = 2.76$ **1 mark**

b. $K_a = [H^+][X^-] / HX \quad K_a = 10^{-2.76} \times 10^{-2.76} / 5.00 \times 10^{-2} = 10^{-4.22} = 6.03 \times 10^{-5}$ **1 mark**

c. If X^- is added, net back reaction **(1 mark)** which uses up H^+ and therefore pH increases. **1 mark**

Question 2 (8 marks)

a. **i.** At equilibrium, the rate of the forward reaction equals the rate of the back reaction. **1 mark**

ii. At equilibrium, the concentration(s) of reactant(s) and product(s) are not changing. **1 mark**

b. $K_c = [NH_3]^2 / [N_2][H_2]^3 \ M^{-2}$ **1 mark** for the constant and **1 mark** for the unit

c. $0.00200^2 / (0.040 \times 0.10^3) = 0.10 \ M^{-2}$ **1 mark**

d. **i.** If a change is made to disturb a system at equilibrium, then the system will, if possible, **partially oppose** the change to restore equilibrium. **1 mark**

ii. The forward reaction is exothermic. If the temperature is increased, the system will move in the direction that will reduce the temperature **1 mark** and therefore a net back reaction will occur so yield is lower. **1 mark**

Question 3 (7 marks)

a. $K_a = [CO][H_2]^3 / [CH_4][H_2O]$ **1 mark**

b. **i.** K increases – system tries to counteract the temperature increase by moving in endothermic direction. The concentration fraction increases permanently. **1 mark**

ii. no change in K as no temperature change **1 mark**

iii. no change in K as no temperature change **1 mark**

c. **i.** increasing in pressure causes the system to try and decrease pressure by a net back reaction. Less products are present at equilibrium. **1 mark**

ii. system tries to counteract the temperature increase by moving in endothermic direction. More product is produced as the forward reaction is endothermic. **1 mark**

iii. The catalyst has no effect on the equilibrium composition – it just speeds up the attainment of equilibrium. **1 mark**

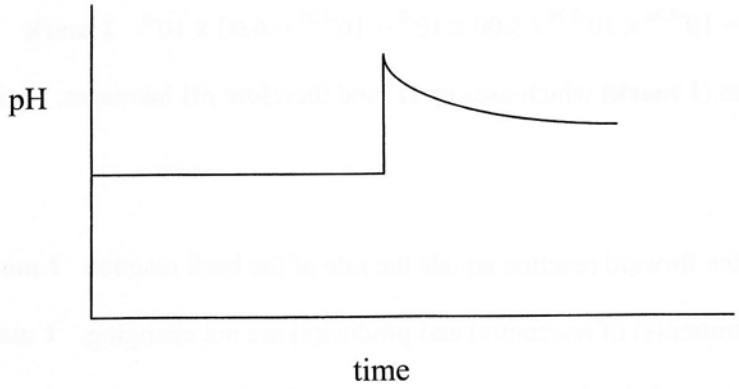
Question 4 (5 marks)

a. $K_a = [H^+][HPO_4^{2-}] / [H_2PO_4^-]$ **1 mark**

b. **i.** If hydrogen ions are added, there will be a net back reaction so that less acid is ionised but the overall pH decreases. **1 mark**

ii. If OH^- ions are added, these will remove H^+ ions and there will be a net forward reaction to partially offset the drop in H^+ but overall pH increases. **1 mark**

c.



1 mark

d. $K_a = [H^+][HPO_4^{2-}] / [H_2PO_4^-]$
$[HPO_4^{2-}] = K_a \times [H_2PO_4^-] / [H^+] = 6.2 \times 10^{-8} \times 0.100 / 10^{-6.9} = 6.2 \times 10^{-2.1} = 4.9 \times 10^{-2}$ M
1 mark

Question 5 (7 marks)

a. **i.** $Fe^{2+}(aq)$ and $I_2(s)$

$Fe^{3+}(aq) / Fe^{2+}(aq)$ +0.77
$I_2(s)$ / $I^-(aq)$ +0.54
$Fe^{2+}(aq) / Fe(s)$ -0.44

For reaction, the oxidant must be higher placed in the ES than the reductant. Although Fe^{2+} occurs in two half-cells, I_2 remains the strongest oxidant and there is no suitable reductant present.
No reaction 1 mark, explanation 1 mark

ii. Sn^{2+} (aq) and $I_2(aq)$

$I_2(aq)$ / $I^-(aq)$ +0.54
$Sn^{4+}(aq)$ / **$Sn^{2+}(aq)$** +0.15
$Sn^{2+}(aq) / Sn(s)$ -0.14

Again Sn^{2+} occurs twice in the ES. This time the strongest oxidant, I_2 is higher placed than the reductant Sn^{2+} and reaction is predicted.

$I_2(s) + Sn^{2+}(aq) \rightarrow 2I^-(aq) + Sn^{4+}(aq)$
1 mark for explanation, 1 mark for balanced equation

iii. oxygenated water and Zn

$O_2(g)$, $H_2O(l)$ / $OH^-(aq)$ +0.40
$Zn^{2+}(aq)$ / **$Zn(s)$** -0.76

The oxidant O_2 is higher placed than the reductant and reaction is predicted.
$O_2(g) + 2H_2O(l) + 2Zn(s) \rightarrow 2\,Zn(OH)_2(s)$
(accept individual ions)
1 mark for explanation, 1 mark for balanced equation

b. Although reaction is predicted, the rate of reaction is too slow. **1 mark**

Question 6 (7 marks)

a. $C_6H_{12}O_6\,(aq) + 6H_2O(l) \rightarrow 6CO_2(g) + 24\,H^+(aq) + 24\,e^-$ **1 mark for balance, 1 mark for states**

b. $E_{cell} = E^o_{(oxidant)} - E^o_{(reductant)} = 1.23 - 0.01 = 1.22\ V$ **1 mark**

c. 1 mol $C_6H_{12}O_6$ = 24 mol of electrons **1 mark**

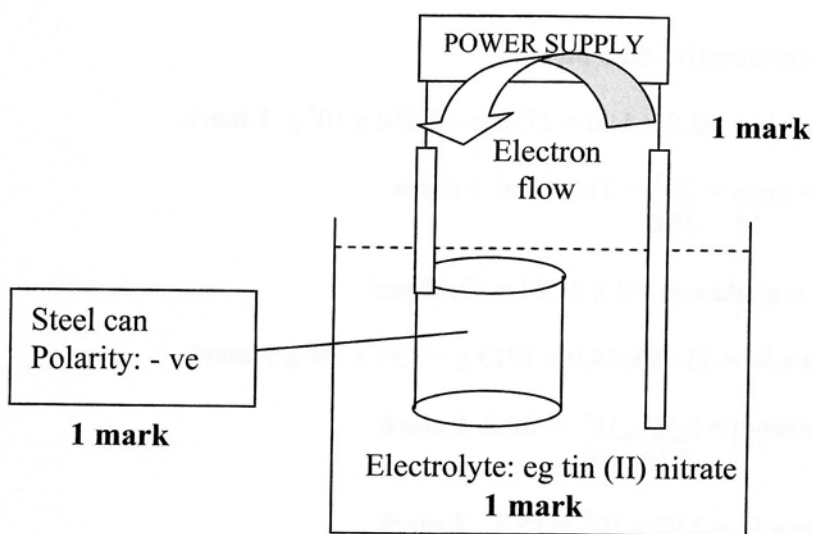
$Q = n(e^-) \times F = 24 \times 96500$ **1 mark**

$E = VQ = 1.22 \times 24 \times 96500 = 2825520\ J = 2.83 \times 10^3\ kJ$ **1 mark**

d. 1 mol $C_6H_{12}O_6$ = 180 g
mass /energy ratio 5.0/180 = **energy** / 2.83 x 10^3 kJ **energy** = 78.6 kJ **1 mark**

Question 7 (7 marks)

a.



1 mark

1 mark

1 mark

b. Using density = m / V

$m(Sn) = d \times V = 7.30 \times 0.41 = 2.993\ g$ **1 mark**

$n(Sn) = \frac{mass}{M} = \frac{2.993}{118.7} = 0.025215$ mol **1 mark**

$Q = I\,t = 3.25 \times 25.0 \times 60 = 4875\ C$

$n(e^-) = \frac{Q}{F} = \frac{4875}{96500} = 0.05052$ mol **1 mark**

$\frac{n(e^-)}{n(Sn)} = \text{charge}$ $\therefore$ $\frac{n(e^-)}{n(Sn)} = \frac{0.05018}{0.0252} = 1.99 = 2$

$\therefore$ the charge on the tin ion is +2 (Sn^{2+}) **1 mark**

Question 8 (11 marks)

a. **i.** Molar mass $CH_4 = 1 \times 12.0 + 4 \times 1.0 = 16.0$ g mol^{-1}

889 kJ of energy is released by 16.0 g of methane
$\therefore \frac{889}{16} = 55.6$ kJ is released by 1.0 g of methane **1 mark**
Hence, 5.56×10^4 kJ of energy is released per kg of methane. **1 mark**

ii. Molar mass $C_2H_5OH = 2 \times 12.0 + 6 \times 1.0 + 1 \times 16.0 = 46.0$ g mol^{-1}

1364 kJ of energy is released by 1 mol of ethanol
$\therefore$ 1364 kJ is released by 46.0 g of ethanol
$\therefore \frac{1364}{46} = 29.7$ kJ is released by 1.0 g of ethanol **1 mark**
Hence, 2.97×10^4 kJ of energy is released per kg of ethanol. **1 mark**

b. **i.** $n(\text{methane}) = \frac{\text{mass}}{M} = \frac{10^3}{16.0} = 62.5$ mol **1 mark**

$n(CO_2) = n$ (methane) $= 62.5$ mol

$m(CO_2) = n \times M = 62.5 \times 44.0 = 2750$ g $= 2.750 \times 10^3$ g **1 mark**

ii. $n(\text{ethanol}) = \frac{\text{mass}}{M} = \frac{10^3}{46.0} = 21.74$ mol **1 mark**

$n(CO_2) = 2 \times n(\text{ethanol}) = 2 \times 21.74 = 43.48$ mol

$m(CO_2) = n \times M = 43.48 \times 44.0 = 1913$ g $= 1.91 \times 10^3$ g **1 mark**

c. CO_2 efficiency (methane) $= \frac{5.56 \times 10^4}{2.75 \times 10^3} = 20.2$ **1 mark**

CO_2 efficiency (ethanol) $= \frac{2.97 \times 10^4}{1.91 \times 10^3} = 15.6$ **1 mark**

Therefore methane would be more useful in terms of CO_2 efficiency based solely on the mass of CO_2 per kg of fuel.

d. Other factors would be the **source** of the fuel. For example, large deposits of methane are generally obtained from gas wells while the ethanol could be obtained from renewable energy sources such as sugar cane. However methane can also be produced in much smaller quantities by rotting sewage. **1 mark**

END OF SUGGESTED SOLUTIONS