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# CHEMISTRY
# Unit 3
# Trial Examination

## SOLUTIONS BOOK

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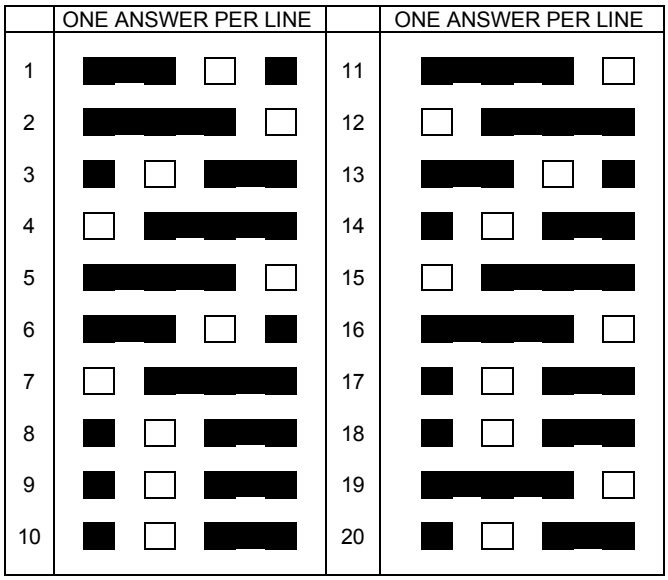
Use this page as an overlay for marking the multiple choice answer sheets. Simply photocopy the page onto an overhead projector sheet. The correct answers are open boxes below. Students should have shaded their answers. Therefore, any open box with shading inside it is correct and scores 1 mark.



**SECTION A (Total 20 marks)**

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

**Comments for Section A answers**

**Question 1**
Solar, wind and hydro energy among others are not plant based. Renewables can be produced at a similar rate to which they are used. **Correct Answer: C**

**Question 2**
Biodiesel has the ability to form dipole-dipole attractions as well as dispersion forces. These allow molecules to stick together more so than other common fuels and may solidify at low temperature. **Correct Answer: D**

**Question 3**
In any exothermic reaction, the total energy of the products is always less than the reactants and the bonds in the products are stronger. **Correct Answer: B**

**Question 4**
$CH_3CH_2OH + 2O_2 \rightarrow 2CO + 3H_2O$ **Correct Answer: A**

**Question 5**
Clearly 4 mol of $H_2$ will produce more energy than 2 mol.
However, it also takes some energy to convert $H_2O(l)$ to $H_2O(g)$.
Therefore maximum amount of energy released is for alternative D. **Correct Answer: D**

**Question 6**
M(hexane) = 86.0 g mol$^{-1}$. From the equation, 8316 kJ for 2 mol of hexane = 2 × 86.0 = 172 g

Using $\frac{\text{m}}{\text{E}}$ ratio: $\frac{172}{8316} = \frac{x}{600}$ $x = \frac{172 \times 600}{8316}$ $x$ = 12.4 g **Correct answer: C**

**Question 7**
Increasing the volume of the conical flask would have no effect on the rate. The other three alternatives would all increase the rate. **Correct Answer: A**

**Question 8**
Although the frequency of collisions increases with increasing temperature, a much greater number of particles have sufficient energy to react. **Correct Answer: B**

**Question 9**
From the overall equation, $\frac{\text{n}(NO_3^-)}{\text{n(Cu)}} = \frac{2}{3}$ $\text{n}(NO_3^-) = \frac{2}{3} \times \text{n(Cu)} = \frac{2}{3} \times 1.0 = 0.67$

**Correct Answer: B**

**Question 10**
$MnO_2$ has Mn in 4+; $MnO_4^{2-}$ has Mn in 6+; Oxidation number of Mn is increased and it is oxidised. **Correct Answer: B**

**Question 11**
Catalysts do not change the equilibrium constant but provide an alternative pathway with a lower activation energy. **Correct Answer: D**

**Question 12**
$K_2 = \frac{1}{(K_1)^2} = \frac{1}{6.60^2} = 0.0230$ **Correct Answer: A**

**Question 13**
The reaction is exothermic so that decreasing the temperature will increase K and more $SO_3$ is produced. **Correct Answer: C**

**Question 14**
W is lower in the ES than all the others. $X^{2+}$ is higher in the series than either Y or Z. Therefore $X^{2+}$ is the strongest oxidant. **Correct Answer: B**

**Question 15**
The hydrogen gas is at 1 atm pressure. **Correct Answer: A**

**Question 16**
Premise: Oxidising agent must be higher placed in the electrochemical series than the reductant. The data below has been extracted from the electrochemical series.

$Cu^{2+}$ / Cu 0.34 V
$Fe^{2+}$ / Fe −0.44 V

The iron is oxidised and the $Cu^{2+}$ ions are reduced. Both $Cu^{2+}$ ions and $Fe^{2+}$ ions will move to the right. **Correct Answer: D**

**Question 17**
Oxidation occurs at the positive electrode in an electrolytic cell. The strongest reductant i.e. Sn will be oxidised. **Correct Answer: B**

**Question 18**
Copper(II) sulfate will be the electrolyte. The silver coin will be the cathode and copper can be used as the anode. **Correct Answer: B**

**Question 19**
$n(e^-) = \frac{Q}{F} = \frac{1500}{96500} = 0.015544$ mol
$n(Ag) = n(e^-)$ ; $m(Ag) = n \times M = 0.015544 \times 107.9 = 1.68$ g
$n(Cr) = ½ \times n(e^-) = 0.007772$; $m(Cr) = n \times M = 0.007772 \times 52.0 = 0.404$ g
$n(Pd) = ½ \times n(e^-) = 0.007772$ ; $m(Pd) = n \times M = 0.007772 \times 106.4 = 0.827$ g
$n(Pb) = ½ \times n(e^-) = 0.07772$ ; $m(Pb) = n \times M = 0.007772 \times 207.2 = 1.61$ g
**Correct Answer: D**

**Question 20** The average can only be given to 2 sf i.e. 2.0 **Correct Answer: B**

**Section B (70 marks)**

**Question 1 (7 marks)**

**a.** **i.** The petrodiesel contains only non-polar bonds between molecules **(1 mark)**. The ester functional group in biodiesel molecules is able to form dipole-dipole interactions **(1 mark)**. These attract molecules of the same kind more strongly **(1 mark)**.

**ii.** At lower temperatures, the ester becomes quite viscous **(1 mark)** because of the dipole-dipole interactions which restricts the flow of fuel and could clog the fuel lines **(1 mark)**.

**b.** Biodiesel is a renewable fuel **(1 mark)** making its use more carbon neutral thus restricting the increase of $CO_2$ into the atmosphere **(1 mark)**.

**Question 2 (4 marks)**

**a.** (+)150 kJ **(1 mark)**. **(Must have unit included for the mark but the + sign is optional)**

**b.** **i.** endothermic **(1 mark)** because the total energy has increased **(1 mark)**

**ii.** decrease **(1 mark)**

**Question 3 (6 marks)**

**a.** $m(CH_4)_{\text{per day}} = 4.126 \times 10^6 \times 10^3 \div 365 = 1.1304 \times 10^7$ g / day **(1 mark)**

$n(CH_4)_{\text{per day}} = \frac{m}{M} = \frac{1.1304 \times 10^7}{16.0} = 7.065 \times 10^5$ mol **(1 mark)**

$V(CH_4)_{\text{per day}} = n \times V_m = 7.065 \times 10^5 \times 24.8 = 1.7521 \times 10^7$ L **(1 mark)**

$= 17.5$ ML **(1 mark)**

**b.** **At constant volume and chemical amount (mol)**

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\frac{P_1}{276.2} = \frac{100}{298}$ **(1 mark)** $P_1 = \frac{100 \times 276.2}{298} = 92.7$ kPa **(1 mark)**

**Question 4 (5 marks)**

**a.** $K = \frac{[NO_2]^2}{[N_2O_4]}$ **(1 mark)**

For **A**, $CF = \frac{0.0385^2}{0.0049} = 0.303$ **(1 mark)**

*does not equal 0.213* so not at equilibrium **(1 mark)**

For **B**, $CF = \frac{0.0299^2}{0.0042} = 0.213$ **(1 mark)** *does equal 0.213* so at equilibrium **(1 mark)**

**b.** In **A**, CF needs to decrease **(1 mark)**. Net back reaction to give more reactants **(1 mark)**.

**Question 5 (7 marks)**

**a.** $VO_2^+$ has V in oxidation state of +5 **(½ mark)**
$VO^{2+}$ has V in oxidation state of +4 **(½ mark)**
$V^{3+}$ has V in oxidation state of +3 **(½ mark)**
$V^{2+}$ has V in oxidation state of +2 **(½ mark)**
$VO_2^+$ has Vanadium in the highest oxidation state **(1 mark)**

**b.** $\mathbf{VO_2^+}(aq) + 2H^+(aq) + e^- \rightleftharpoons \mathbf{VO^{2+}}(aq) + H_2O(l)$ $E^o = +1.02$ V
$\mathbf{I_2(s)} + 2e^- \rightleftharpoons \mathbf{2I^-(aq)}$ $E^o = +0.54$ V
$\mathbf{VO^{2+}}(aq) + 2H^+(aq) + e^- \rightleftharpoons \mathbf{V^{3+}}(aq) + H_2O(l)$ $E^o = +0.34$ V
$\mathbf{V^{3+}}(aq) + e^- \rightleftharpoons \mathbf{V^{2+}}$ $E^o = -0.25$ V

Since the oxidant has to be higher placed than the reductant to predict reaction **(1 mark) (or any similar justification)**, only $\mathbf{VO_2^+}$ can oxidise $I^-$ **(1 mark)**.

**Question 6 (7 marks)**

**a.**

| | increase in concentration | increase in volume | increase in temperature | addition of suitable catalyst |
|---|---|---|---|---|
| collision frequency | ↑ | ↓ | ↑ | — |
| collision energy | — | — | ↑ | — |
| activation energy barrier | — | — | — | ↓ |

**(1 mark for each column if all correct = 4 marks)**

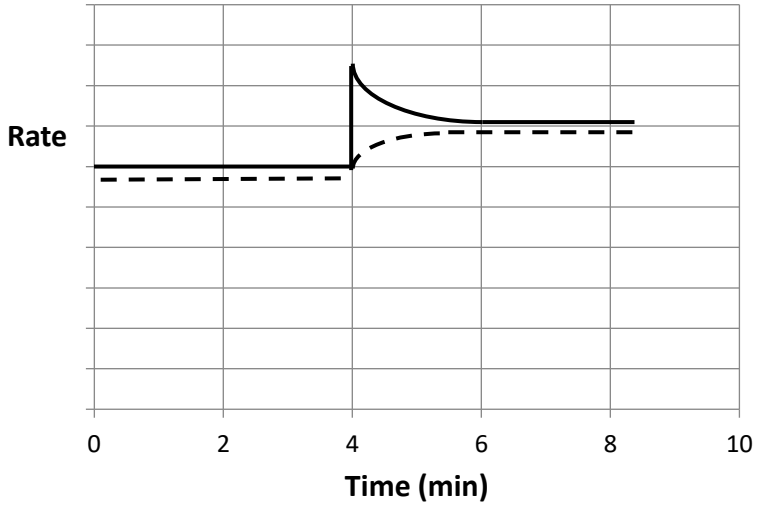
**b.** A proportion of molecules do not have sufficient energy to reach the activation energy **(1 mark)**.
Some collisions are not in the appropriate orientation **(1 mark)**.

**c.** An increase in volume causes less collisions per second in the increased volume **(1 mark)** so collision frequency decreases.

**Question 7 (5 marks)**

**a.** Heat or cool the solution **(1 mark)**. If heated and the forward reaction is endothermic, the reaction will favour the product side to attempt to reduce the temperature and the solution will become more blue **(1 mark)**.
Alternatively, if cooled and the forward reaction is endothermic, the reaction will favour the reactant side to increase the temperature and the solution will become more pink.

**b.**




**(1 mark for forward rate increasing sharply)**
**(1 mark for both rates increasing)**
**(1 mark for again reaching equilibrium at 6 min)**

**Question 8 (7 marks)**

**a.** $K = \frac{[Cl_2]^2[H_2O]^2}{[HCl]^4[O_2]}$ **(1 mark)**

**b.** $4HCl(g) + O_2(g) \leftrightharpoons 2Cl_2(g) + 2H_2O(g)$

| | | | | | |
|---|---|---|---|---|---|
| $n_{initial}$ | 0.800 | 0.200 | 0.000 | 0.000 | |
| $n_{reacting}$ | 0.600 | 0.150 | | | **(1 mark)** |
| $n_{produced}$ | | | 0.300 | 0.300 | |
| $n_{equilibrium}$ | 0.200 | 0.0500 | 0.300 | 0.300 | **(1 mark)** |
| $C_{equilibrium}$ | 0.0200 | 0.0050 | 0.0300 | 0.0300 | **(1 mark)** |

**c.** $K = \frac{0.0300^2 \times 0.0300^2}{0.0200^4 \times 0.0050} = 1.01 \times 10^3$ **(1 mark)** $M^{-1}$ **(1 mark)**

**d.** Net back reaction would occur and / or more reactants would form **(1 mark)**

**Question 9 (13 marks)**

**a.** $PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$ **(1 mark)**

**b.** The −ve electrode on the cell is connected to the −ve electrode on the charger and the +ve electrode on the cell is connected to the +ve electrode on the charger **(1 mark)**. Supply greater than the voltage of the cell **(1 mark)**.

**c.** $PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq)$ **(1 mark)**

**d.**

| | discharge only | recharge only | during both | during neither |
|---|---|---|---|---|
| Electrons flow from electrode 1 to electrode 2. | ✓ | | | |
| Electrode 2 is the negative (−) electrode. | | | | ✓ |
| Electrical energy is converted into chemical energy. | | ✓ | | |
| The cathode is the electrode at which oxidation occurs. | | | | ✓ |
| Electrode 1 is the anode. | ✓ | | | |
| Anions in the acid solution migrate towards electrode 1. | ✓ | | | |
| The mass of electrode 2 increases. | ✓ | | | |
| Reduction occurs at electrode 1. | | ✓ | | |
| The pH of the electrolyte solution decreases. | | ✓ | | |

**(1 mark per correct response = 9 marks)**

**Question 10 (4 marks)**

**a.** $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ **(1 mark for correct balance, 1 mark for states)**

**b.** $C_3H_8(g) + 6H_2O(l) \rightarrow 3CO_2(g) + 20H^+(aq) + 20e^-$ **(1 mark)**

**c.** $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ **(1 mark)**

**Question 11 (5 marks)**

$Q = I \times t = 2.2 \times 25 \times 60 = 3.3 \times 10^3$ C **(1 mark)**

$n(e^-) = \frac{Q}{F} = \frac{3.3 \times 10^3}{96500} = 0.03420$ mol **(1 mark)**

$n(Cr) = \frac{m}{M} = \frac{0.59}{52.0} = 0.01135$ mol **(1 mark)**

$\frac{n(e^-)}{n(Cr)} = \frac{0.03420}{0.01135} = 3.0 = 3$ **(1 mark)** i.e. $Cr^{3+}$ **(1 mark)**

**END OF SUGGESTED SOLUTIONS**