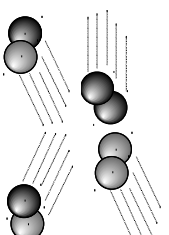
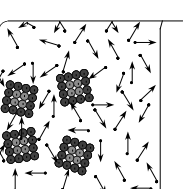


# Higher Chemistry



Topic 3:



## Equilibrium & Industry

# Answer Book

3.1	A	B	C	D
1		■		
2			■	
3			■	
4				■
5			■	
6				■
7		■		
8				

3.2	A	B	C	D
1		■		
2			■	
3			■	
4				■
5			■	
6				■
7		■		
8				

3.3	A	B	C	D
1		■		
2			■	
3			■	
4				■
5			■	
6				■
7		■		
8				

3.5	A	B	C	D
1				■
2			■	
3			■	
4		■		
5			■	
6				■
7		■		
8				

3.6	A	B	C	D
1		■		
2			■	
3			■	
4				■
5			■	
6				■
7		■		
8				

3.7	A	B	C	D
1		■		
2			■	
3			■	
4		■		
5			■	
6				■
7		■		
8				

# HOME PRACTICE

## 3.1

<b>Q1. a)</b>	The reaction is reversible. <b>OR</b> It can go in either direction.	<b>1</b>
<b>b)</b>	To the left. <b>OR</b> in reverse.	<b>1</b>
<b>c)</b>	Must be a closed system <b>OR</b> None of the chemicals can escape/ must remain to react	<b>1</b>
<b>Q2. a)</b>	To the left	<b>1</b>
<b>b)</b>	The forward and reverse reactions both continue.	<b>1</b>
<b>c)</b>	The rates of the forward and reverse reactions?	<b>1</b>
<b>d)</b>	20 %	<b>1</b>
<b>Q3. a)</b>	$\text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}^+_{(aq)} + \text{OH}^-_{(aq)}$	<b>1</b>
<b>b)</b>	Well over to the left.	<b>1</b>
<b>c)</b>	The reverse reaction is favoured.	<b>1</b>
<b>Total</b>		<b>(10)</b>

# CONSOLIDATION ANSWERS

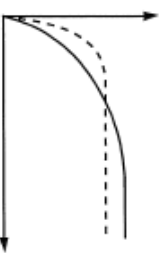
## D

<b>Q1. a)</b>	$K = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]}$	<b>1</b>
<b>b)</b>	Decrease <b>K</b> (½) Because $[\text{SO}_3]$ less, and $[\text{SO}_2]$ and $[\text{O}_2]$ more (when the equilibrium position shifts to left) (½)	<b>1</b>
<b>c)</b>	None <b>or</b> No effect (½) Because $[\text{SO}_3]$ same, and $[\text{SO}_2]$ and $[\text{O}_2]$ same since a catalyst does not affect equilibrium position (½)	<b>1</b>
<b>Q2. a)</b>	A feedstock is any reactant fed in whereas a raw material is a substance found naturally. (½)	<b>1</b>
<b>b)</b>	Air	<b>1</b>
<b>c)</b>	Any <b>two</b> from construction costs of: the plant offices staff canteen security entrances roadways car parking areas	<b>1</b>
<b>d)</b>	<b>or</b> other suitable example [(½) each, max (1)] wages / salaries of employed staff rates / local authority charges depreciation catalyst licences product advertising catering services overheads / heating and lighting other suitable example [(½) each, max (1)]	<b>1</b>
<b>Q3. a)</b>	Exothermic	<b>1</b>
<b>b)</b>	<b>X:</b> 240 °C (½) <b>Y:</b> 240 °C (½)	<b>1</b>
<b>c)</b>	200 °C	<b>1</b>

## CONSOLIDATION ANSWERS

**C**

Q1. a)



[Dotted graph rises more steeply (½) but levels out lower. (½)]

[Labels not required]

1

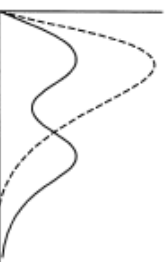
b) The hydroxide ions neutralise the hydrogen ions (½) but the continuing forward reaction increases the iodide concentration. (½)

1

Q2. a) It is the safe range (½) in which the drug functions. (½).

1

b)



[Dotted graph with only one peak (½) rising to about twice the height. (½)]

[Labels not required]

1

c) The concentration of drug (in the plasma) could increase beyond the safe limit / above the therapeutic window (½) causing toxic effects / death / unhealthy side effects. (½)

1

Q3.



a) 1 mole  $\longrightarrow$  2 moles (½)

160 g  $\longrightarrow$  112 g (½)

320 g  $\longrightarrow$  224 g (½)

320 tonnes  $\longrightarrow$  224 tonnes (½)

2

b)

$$\text{Yield} = \frac{\text{actual product mass}}{\text{theoretical product mass}} \times 100 \%$$

$$\text{Yield} = \frac{150}{224} \times 100 = 67 \%$$

1

c)

$$\text{Atom Economy} = \frac{\text{mass of desired product(s)}}{\text{total mass of reactants}} \times 100$$

Can work with molar masses but to allow for 67 % yield must use 150 g for 2 Fe rather than 'expected' 224 g. (½)

$$\text{Atom economy} = \frac{150}{160 + 84} \times 100$$

$$= \frac{150}{244} \times 100$$

$$= 61.5 \%$$

(½)

(1)

2

## HOME PRACTICE ANSWERS

**3.2**

Q1. a) The red/brown colour will become stronger.

1

b) i)  $\text{H}^+$  (aq)

1

ii) The reverse reaction will slow down as  $\text{H}^+$  (aq) ions are removed.

OR The forward reaction will speed up to replace the  $\text{H}^+$  (aq)

1

iii) The red/brown colour will fade.

OR It will turn colourless.

1

Q2. a) Shift to the left OR more reactants OR less products

1

b) It is endothermic

1

c) No effect on position (it simply allows equilibrium to be reached faster)

1

Q3. a) Shift to the left (favours the endothermic reverse reaction)

1

b) High pressure would favour reaction with largest number of moles of gas (the reverse reaction) so equilibrium would shift to the left giving less product.

1

c) To achieve equilibrium quicker.

1

**Total (10)**

**HOME PRACTICE ANSWERS****3.3**

- Q1. a)** Used an ink pen instead of pencil (ink could 'run').  
Solvent (water) is above the base line. **1**
- b)** Copper (II) -  $\text{Cu}^{2+}$  and Iron(III) -  $\text{Fe}^{3+}$  **1**
- c)**  $\text{Cu}(\text{OH})_2$  or  $\text{Cu}^{2+}(\text{OH})_2$  **1**
- d)** Blue **1**
- e)**
- |  |                        |
|--|------------------------|
| distance moved by spot X from base line  | <b>23 mm or 2.3 cm</b> |
| distance moved by solvent from base line | <b>56 mm or 5.6 cm</b> |
- 2**
- f)**
- $$R_f = \frac{\text{distance traveled by compound (cm)}}{\text{distance traveled by solvent (cm)}}$$
- $$R_f = 23 / 56 = 0.41$$
- g)** The spot with an  $R_f$  of 0.54 could equally be **B** or **D**. **1**
- h)** **Either** Run a second chromatogram using either ethanol or propanone as the solvent as B and D have totally different  $R_f$  values with these solvents. **1**
- Or** Run a chromatogram with B, D and the pain killer all on the same sheet **1**  
and see which substances travel exactly the same distance. **1**
- Total (10)**

**CONSOLIDATION ANSWERS****B**

- Q1. a)** Move (the equilibrium position) to the right. **1**
- b)** Move (the equilibrium position) to the left. **1**
- Q2. a)** - 36 kJ [-(½) if no, or incorrect, unit] **1**
- b)** +36 kJ **or** 36 kJ [-(½) if no, or incorrect, unit] **1**
- Q3. a)** Any **two** from:  
toothpaste for healthy / sparkling teeth  
shampoo for clean/ good-looking hair  
cleansing creams for healthy / good-looking skin  
shaving creams for a pleasant smooth shave  
mouth washes for healthy mouth / fresh breath  
antiseptics for cleaning cuts and grazes  
bath salts for invigorating /relaxing bath  
shower gel for invigorating / cleansing shower  
other suitable toiletry and benefit [(½) each, max (1)] **1**
- or**
- b)** Expensive to set up (½) and employs few people (½) [or Similar] **1**
- Q4. a)** Exothermic **1**
- b)** To remove heat (½) **or** so that the plant does not overheat (½) for a better (equilibrium) yield. (½) **1**
- c)** 1.5(%) [35% of 35% of 35% of 100 = 1.5] **2**

**CONSOLIDATION ANSWERS****A**

- Q1.** *a)* The rate of forward and reverse reactions (must be equal). 1  
*b)* The forward and reverse reactions both continue. 1  
*c)* Sulphurous acid 1
- Q2.** *a)* The greater the pressure, the smaller the proportion of reactant gases (at equilibrium).  
*Or* The smaller the pressure, the greater the proportion of reactant gases (at equilibrium). 1  
*b)* 52 % [Accept in the range 50 to 54 %] 1  
*c)* They are recycled. *or* A recycle loop is used. 1
- Q3.** *a)* To improve the Atom Economy 1  
*b)* Capital (costs) 1  
*c)* Chromatography 1  
*d)* Any one from:  
 effectiveness of the drug  
 possible side-effects  
 health and safety procedures (when manufacturing)  
 environmental effects for waste materials  
 energy costs / savings  
 product yield  
 income in relation to costs 1

**HOME PRACTICE ANSWERS****3.5**

- Q1.** *a)* Feedstock (½) 1  
*b)* Raw material (½) 1  
*c)* Raw material (½) 1  
*d)* Catalyst (½) 1
- Q2.** *a)* No effect *or* None 1  
*b)* Decreases it *or* Lowers it 1  
*c)* Increases it *or* Raises it 1  
*d)* The rate of the reaction becomes too slow 1  
 It is too costly to build, run and maintain a plant operating at such a high pressure. 1
- Q3.** *a)* Nitrogen and hydrogen *or* Unreacted gases 1  
*b)* To avoid wasting valuable feedstocks 1  
*c)* By cooling - the ammonia is liquified and can be drained off 1
- Total (10)**

# HOME PRACTICE ANSWERS

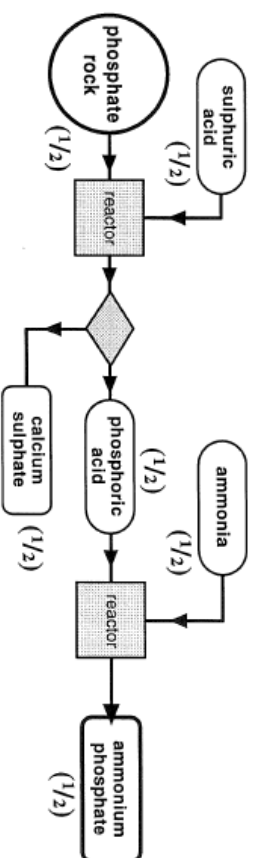
## 3.6

- Q1. a) 

① Raw Material	(½)
② Raw Material	(½)
③ By-product	(½)
④ By-product	(½)
- b) To use up sulphur dioxide (½) which would cause acid rain if released into the atmosphere. (½)

2

1



- b) 

i) phosphate rock	(½)
ii) calcium sulphate	(½)
iii) phosphoric acid	(½)
iv) ammonium phosphate	(½)
- c) 

i) capital cost	(½)
ii) variable cost	(½)
iii) fixed cost	(½)
iv) variable cost	(½)
- Total (10)**

3

2

2

**Total (10)**

# HOME PRACTICE ANSWERS

## 3.7

- Q1. a) Produces less waste and makes process more sustainable. 1
- b) Atom economy = 40% so waste = 60% 1
- 60 % of 3000 tonnes = 1800 tonnes 1
- c) Atom economy = 77% so waste = 23% 1
- 23 % of 3000 tonnes = 690 tonnes so 1110 tonnes less waste 1



- a) 

2 moles	$\longrightarrow$	1 mole	(½)
34 g	$\longrightarrow$	32 g	(1)
340 g	$\longrightarrow$	320 g	(½)

2

$$\text{Yield} = \frac{\text{actual product mass}}{\text{theoretical product mass}} \times 100 \%$$

$$\text{Yield} = 280 / 320 \times 100 = 87.5\%$$

1

$$\text{Atom Economy} = \frac{\text{mass of desired product(s)}}{\text{total mass of reactants}} \times 100$$

Can work with molar masses but to allow for 87.5 % yield must use 28g for  $\text{N}_2\text{H}_4$  rather than 'expected' 32g. (½)

$$\begin{aligned} \text{Atom economy} &= 28 / (34 + 74.5) \times 100 && (\frac{1}{2}) \\ &= 28 / (108.5) \times 100 && (\frac{1}{2}) \\ &= 25.8\% && (1) \end{aligned}$$

2

**Total (10)**