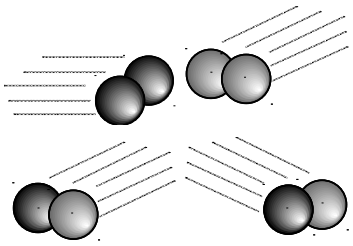
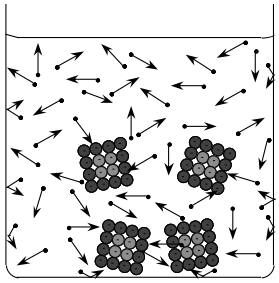
Higher Chemistry





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

Q1. ***a)*** The reaction is reversible**.**
OR It can go in either direction**.** **1**

b) To the left**.**
OR in reverse**.** **1**

c) Must be a closed system
OR None of the chemicals can escape/ must remain to react **1**

Q2. ***a)*** To the left **1**

b) The forward and reverse reactions both continue. **1**

c) The rates of the forward and reverse reactions? **1**

d) 20 % **1**

Q3. ***a)*** $H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$ **1**

b) Well over to the left. **1**

c) The reverse reaction is favoured. **1**

Total ***(10)***

HOME PRACTICE ANSWERS 3.2

Q1. ***a)*** The red/brown colour will become stronger. **1**

b) ***i)*** $H^+_{(aq)}$ **1**

ii) The reverse reaction will slow down as $H^+_{(aq)}$ ions are removed.
OR The forward reaction will speed up to replace the $H^+_{(aq)}$ **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) - Cu^{2+} and Iron(III) - Fe^{3+} **1**

c) $Cu(OH)_2$ or $Cu^{2+}(OH^-)_2$ **1**

d) Blue **1**

e)

distance moved by spot **X** from base line	**23 mm or 2.3 cm**
distance moved by solvent from base line	**56 mm or 5.6 cm**

2

f)

$$R_f = \frac{\text{distance traveled by compound (cm)}}{\text{distance traveled by solvent (cm)}}$$

R_f = 23 / 56 = 0.41 **1**

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 **1**

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)***

HOME PRACTICE ANSWERS 3.5

Q1. ***a)*** Feedstock (½)

b) Raw material (½)

c) Raw material (½)

d) Catalyst (½)

2

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**

d) 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

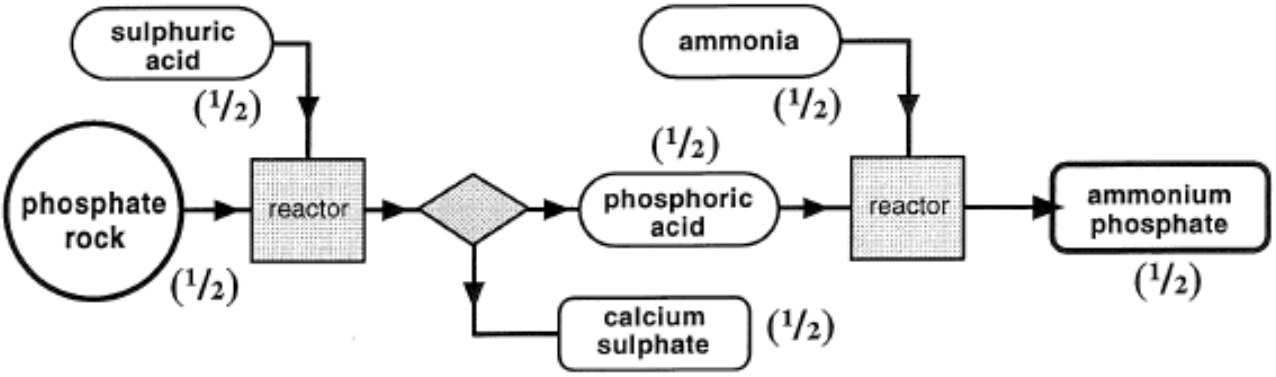
Q1. ***a)***

①	Raw Material	(½)
②	Raw Material	(½)
③	By-product	(½)
④	By-product	(½)

2

b) To use up sulphur dioxide (½) which would cause acid rain if released into the atmosphere. (½) **1**

Q2. ***a)***



3

b)

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

2

c)

i)	capital cost	(½)
ii)	variable cost	(½)
iii)	fixed cost	(½)
iv)	variable cost	(½)

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**

Q2. $2NH_3 + NaClO \longrightarrow N_2H_4 + NaCl + H_2O$

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

34 g $\longrightarrow$ 32 g (1)

340 g $\longrightarrow$ 320 g (½) **2**

b)

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

Yield = 280 / 320 x 100 = 87.5 % **1**

c)

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

Can work with molar masses but to allow for 87.5 % yield must use 28g for N_2H_4 rather than 'expected' 32g. (½)

Atom economy = 28 / (34 + 74.5) x 100

= 28 /(108.5) x100 (½)

= 25.8 % (1)

2

Total ***(10)***

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) Chtromatography **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**

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

or other suitable toiletry and benefit [(½) each, max (1)] **1**

b) Expensive to set up (½) and employs few people (½)

[***or*** Similar] **1**

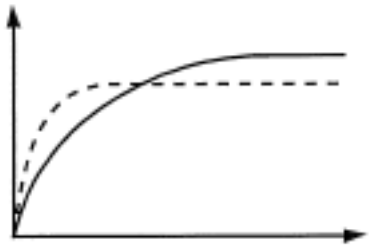
Q4. ***a)*** Exothermic **1**

b) To remove heat (½) so that the plant does not overheat (½)
or for a better (equilibrium) yield. (½) **1**

c) 1.5(%) [35% of 35% of 35% of 35% of 100 = 1.5] **2**

CONSOLIDATION ANSWERS C

Q1. ***a)***



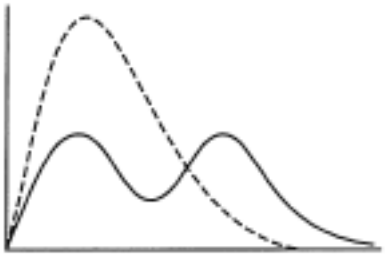
[Dotted graph rises more steeply (½) but levels out lower. (½)]

[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.

$$Fe_2O_3 + 3\,CO \longrightarrow 2\,Fe + 3\,CO_2$$

a)

1 mole	⟶	2 moles	(½)
160 g	⟶	112 g	(½)
320 g	⟶	224 g	(½)
320 tonnes	⟶	224 tonnes	(½)

2

b)

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

Yield = 150/224 x 100 = 67 % **1**

c)

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

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

Atom economy	=	150 / (160 + 84) x 100	
	=	150 /(244) x100	(½)
	=	61.5 %	(1)

2

CONSOLIDATION ANSWERS D

Q1. ***a)***

$$\mathbf{K} = \frac{[SO_3]^2}{[SO_2]^2\,[O_2]}$$

1

b) Decrease **K** (½)

Because $[SO_3]$ less, and $[SO_2]$ and $[O_2]$ more (when the equilibrium position shifts to left) (½) **1**

c) None ***or*** No effect (½)

Because $[SO_3]$ same, and $[SO_2]$ and $[O_2]$ same since a catalyst does not affect equilibrium position (½) **1**

Q2. ***a)*** A feedstock is any reactant fed in (½)
whereas a raw material is a substance found naturally. (½) **1**

b) Air **1**

c) Any ***two*** from construction costs of:

the plant
offices
staff canteen
security entrances
roadways
car parking areas

or other suitable example [(½) each, max (1)] **1**

d) Any ***two*** from:

wages / salaries of employed staff
rates / local authority charges
depreciation
catalyst licences
product advertising
catering services
overheads / heating and lighting

or other suitable example [(½) each, max (1)] **1**

Q3. ***a)*** Exothermic **1**

b) **X:** 240 °C (½)

Y: 240 °C (½) **1**

c) 200 °C **1**