Mark schemes

Q1.

(a) (test) add barium chloride (solution)

ignore (hydrochloric / nitric / sulfuric) acid

allow add barium nitrate (solution)

1

(result) white precipitate

MP2 is dependent upon MP1 being awarded

1

(b) the yield is smaller at higher temperatures because the reaction is exothermic

1

(c) there are more moles / molecules (of gas) on the left

allow converse

ignore particles

1

(so the position of) equilibrium shifts to the right

1

(d) any **two** from:

- the yield is already high
- more energy required
- risk of explosion is increased
- higher income from increased yield is outweighed by the extra expenditure
- increased cost of safety precautions

allow requires stronger vessels

allow requires thicker walls

2

(e) vanadium (V)

1

[8]

Q2.

(a) (mass of water in 4.68 g = 4.68 - 2.99) = 1.69 (g)

1

(mass of water in 11.7 g =)

$$\frac{11.7}{4.68} \times 1.69$$

allow correct use of an incorrectly determined mass of water in 4.68 g

1

= 4.23 (g)

allow 4.2 / 4.225 (g)

1

alternative approach:

(mass of anhydrous compound =

$$\frac{11.7}{4.68} \times 2.99)$$

= 7.475 (g) (1)

(mass of water =)
11.7 - 7.475 (1)

allow correct use of an incorrectly determined mass of anhydrous compound

= 4.23 (g) (1)

allow 4.2 / 4.225 (g)

(b) (energy =)

$$\frac{15.0}{2.99} \times 1.47$$

1

= 7.37 (kJ)

allow 7.37458194 correctly rounded to at least 2 significant figures

1

(c) shifts to the left

1

(d) the mixture is a lighter shade of brown

1

(e) no effect (on equilibrium position)

allow (equilibrium position) stays the same

1

(because) there are equal numbers of (gas) moles / molecules on each side (of the equation)

1

(f) no effect (on equilibrium position)

allow (equilibrium position) stays the same

1

(g) add more hydrochloric acid

1

(h) (because the) forward and reverse reactions are taking place at (exactly) the same rate

2

ignore references to closed systems

*allow for **1** mark*

(because) the reactions are taking place at (exactly) the same rate

[13]

Q3.

(a) (nitrogen) air

allow atmosphere

1

(hydrogen) natural gas

allow methane

allow water / steam

1

(b) there is only one product

1

(c) (mixture is) cooled

1

(so that only) ammonia liquefies

allow (so that only) ammonia condenses

1

(d) scale labelled at 100, 200, 300 and 400 (atm)

allow scale labelled at 50, 150, 250 and 350 (atm)

1

all five points plotted correctly

allow a tolerance of ± ½ a small square

*allow **1** mark for three / four points plotted correctly*

2

line of best fit

1

(e) **View with Figure 2**

extrapolation to 500 atmospheres

1

percentage value at 500 atmospheres

allow a tolerance of ± ½ a small square

1

(f) **Level 3**: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.

5–6

Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

3–4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

1–2

No relevant content

0

Indicative content

rate
- higher temperature gives higher rate because of more frequent collisions
- higher temperature gives higher rate because more particles have the activation energy
- higher pressure gives higher rate because of more frequent collisions
- use of catalyst gives higher rate because the activation energy is lowered

equilibrium
- higher temperature shifts the position of equilibrium to the left because reaction is exothermic
- higher pressure shifts the position of equilibrium to the right because more molecules on left-hand side
- use of catalyst has no effect on the position of equilibrium

other factors
- higher temperature (than 450°C) uses more energy so increases costs
- higher pressure (than 200 atmospheres) uses more energy so increases costs
- higher pressure (than 200 atmospheres) requires stronger reaction vessels so increases costs
- use of a catalyst reduces energy costs

compromise
- the temperature chosen is a compromise between rate of reaction and position of equilibrium
- the temperature chosen is a compromise between rate and cost
- the pressure chosen is a compromise between yield / rate and cost

[17]