

(The Haber process (conditions, yield, equilibrium))

Q1. a). (2018)

hydrogen

Q1. b). (2018)

450 °C

200 atm / atmospheres

Q1. c). (2018)

ammonia has a higher boiling
point

Q2. a). (2019)

$$\frac{6}{34} \times 100$$

$$= 17.6 (\%)$$

Q2. b). (2019)

higher yield (of hydrogen or
carbon monoxide or product)

(because) fewer moles /
molecules / particles on left
hand side

or

(because) more moles /
molecules / particles on right
hand side

Q2. c). (2019)

no effect (on yield of hydrogen)

Q3. a). (2019)

350 (°C) and 285 (atmospheres)
= 63 (%)

and

450 (°C) and 200 (atmospheres)
= 28 (%)

$$\frac{63}{28}$$

= 2.25 (times greater)

Q3. b). (2019)

any **one** from:

- the energy costs would be high(er)
- the equipment would need to be strong(er)
- high(er) pressures are (more) dangerous

Q3. c). (2019)

higher temperatures produce a lower (percentage) yield (of ammonia)

Q4. (2022)

(nitrogen) air

(hydrogen) natural gas

Q5. (2022)

there is only one product

Q6. (2022)

(mixture is) cooled

(so that only) ammonia liquefies

Using Resources

<http://www.pcfgstudy.com>

Q7. a). (2022)

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

all five points plotted correctly

line of best fit

Q7. b). (2022)

extrapolation to 500
atmospheres

percentage value at 500
atmospheres

Q8. (2022)

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

Q9. a). (2024)

to recycle (remaining) nitrogen
and hydrogen

Q9. b). (2024)

iron