

Question 17 (Answer: **A**)

- The Contact process makes sulfur trioxide from sulfur dioxide and oxygen.
- All three species are gases in the converter, so all are labelled (g).
- $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ – and SO_4 does not exist as a molecule.

Question 19 (Answer: **C**)

- There are 4 moles of gas on the left and 2 on the right, so high pressure favours ammonia.
- The forward reaction is exothermic, so a *low* temperature favours ammonia.
- So increasing the pressure and decreasing the temperature both raise the yield.

Question 18 (Answer: **C**)

- The forward reaction is endothermic, so *raising* the temperature shifts it to the right.
- More NO_2 means the mixture turns browner.
- Raising the pressure would shift it left, since there are fewer gas moles on that side, turning it paler.

Question 19 (Answer: **A**)

- There are 2 moles of gas on the left and 1 on the right, so high pressure favours the ethanol.
- The forward reaction is exothermic, so a *low* temperature favours the ethanol.
- So raising the pressure and lowering the temperature both increase the equilibrium yield.

Question 20 (Answer: **B**)

- The Contact process uses a vanadium(V) oxide catalyst – iron belongs to the Haber process.
- The pressure used is only slightly above atmospheric, about 200 kPa.
- A very high pressure is unnecessary here and would add cost for little gain.

4(a)	M1 energy level of products below energy level of reactants M2 label of $\text{SO}_2(\text{g}) + 4\text{HF}(\text{g})$ on product line M3 upward arrow labelled E_a from energy level of reactants to the highest point of the curve M4 one downward arrow labelled ΔH AND energy change starting from energy level of reactants and finishing at energy level of products
4(b)	M1 = $(4 \times \text{S-F}) + (4 \times \text{O-H}) = (4 \times 330) + (4 \times 460) = 3160$ M2 bond energy of products – $3160 = -54$ = $3160 - (-54) = 3214$ M3 $(2 \times \text{S=O}) + (4 \times \text{H-F}) = 3214$ therefore $2 \times \text{S=O} = 3214 - (4 \times 570) = 934$ M4 $\text{S=O} = 934 \div 2 = 467$
4(c)	increased temperature: M1 (position of) equilibrium moves to left hand side M2 reaction is exothermic increased pressure: M3 (position of) equilibrium moves to left hand side M4 less (gaseous) moles on left hand side M5 no change / catalyst does not affect position of equilibrium
4(d)	M1 kinetic energy of particles decreases M2 frequency of collisions between particles decreases M3 lower percentage/proportion/fraction of collisions / particles have energy greater than / equal to activation energy

Question 16 (Answer: **B**)

- The forward reaction is exothermic, so a low temperature would give the best yield – but far too slowly.
- 450°C is a compromise between yield and rate.
- High pressure genuinely favours the forward reaction, since there are fewer moles of gas on the right.

Question 16 (Answer: **D**)

- The mixture's colour tells you which species dominates at equilibrium.
- Adding more of a reactant shifts the position to the right, deepening the red.
- Removing a reactant shifts it left, so the red fades towards yellow.

5(a)	M1 concentration is no longer changing M2 rates of forward reaction and of the reverse reaction are equal
5(b)(i)	M1 rate decreases M2 yield of methanol decreases
5(b)(ii)	no change(1) increases (1)
5(b)(iii)	exothermic
5(b)(iv)	M1 copper M2 transition element
5(c)(i)	any 2 from: - same or similar chemical properties or reactions (same) general formula (consecutive members) differ by CH₂ - same functional group - physical properties OR example of a physical property e.g. melting point / boiling point / volatility vary in predictable manner or show trends or gradually change
5(c)(ii)	C ₈ H ₁₂ O
5(d)(i)	M1 displayed formula of ester linkage, i.e. $\text{H or C} - \overset{\text{O}}{\underset{\text{ }}{\text{C}}} - \text{O} - \text{C}$ M2 completely correct displayed formula of methyl ethanoate or ethyl methanoate i.e. $\begin{array}{c} \text{H} & \text{O} & \text{H} \\ & & \\ \text{H} - \text{C} - & \text{C} - \text{O} - & \text{C} - \text{H} \\ & & \\ \text{H} & & \text{H} \end{array}$ OR $\begin{array}{c} \text{O} & \text{H} & \text{H} \\ & & \\ \text{H} - \text{C} - \text{O} - & \text{C} - & \text{C} - \text{H} \\ & & \\ & \text{H} & \text{H} \end{array}$
5(d)(ii)	M1 butan-1-ol M2 ethanoic acid

5(e)	M1 C 64.87 / 12 H 13.51 / 1 O 21.62 / 16 OR 5.41 13.51 1.35 M2 C ₄ H ₁₀ O
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Question 20 (Answer: **D**)

- The forward reaction is exothermic, so *lowering* the temperature shifts it right.
- There are 9 moles of gas on the left and 10 on the right, so going forwards increases the volume.
- *Lowering* the pressure therefore also shifts it right.