



IB Chemistry – SL

Topic 7 Answers

1. D
2. B
3. B
4. D
5. D
6. A
7. C
8. B
9. A
10. B
11. C
12. C
13. D
14. B
15. D
16. C
17. A
18. B
19. A
20. C
21. D
22. C
23. C
24. D
25. (a) 200°C 600 atm. (*both for [I], units not needed*); 1
allow the “highest pressure and the lowest temperature”
- (b) (i) yield increases/equilibrium moves to the right/more ammonia; 2
4 (gas) molecules → 2/decrease in volume/fewer molecules on right hand side;
- (ii) yield decreases/equilibrium moves to the left/less ammonia;
exothermic reaction/*OWTTE*; 2

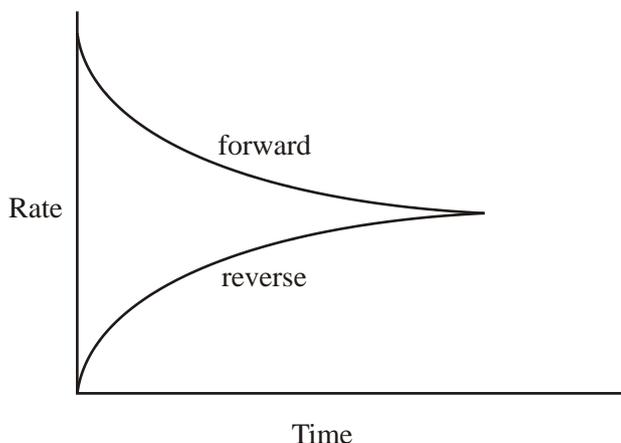


- (c) high pressure expensive/greater cost of operating at high pressure/reinforced pipes *etc.* needed;
lower temperature – greater yield, but **lowers** rate;
Do not award a mark just for the word “compromise”. 2
- (d) $K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$ (*ignore units*); 1
- [8]
26. (a) (position of) equilibrium shifts to the left/towards reactants; (forward) reaction is exothermic/ ΔH is negative/the reverse reaction is endothermic/*OWTTE*;
Do not accept “Le Chatelier’s Principle” without some additional explanation. 2
- (b) (position of) equilibrium shifts to the right/towards products;
fewer gas molecules on the right hand side/volume decreases in forward reaction/*OWTTE*;
Do not accept “Le Chatelier’s Principle” without some additional explanation. 2
- [4]
27. (a) $(k_c) = \frac{[\text{NH}_3]^2}{[\text{H}_2]^3[\text{N}_2]}$; 1
Do not allow round brackets unless K_p is used.
- (b) equilibrium shifts to the right/products;
4 mol \rightarrow 2 mol of gas/fewer moles of gas on the right/products; 2
- (c) K_c decreases;
equilibrium position shifts to the left/reactants/forward reaction is exothermic /reverse reaction is endothermic; 2
- (d) catalyst increases the rate of the forward and backward reactions equally /lowers the activation energy of both forward and backward reaction equally /lowers E_a so rate of forward and backward reactions increase; 1



[6]

28. (a)



two curves – one labelled “forward” starting up high up y-axis and one labelled “reverse” starting from zero;
curves merge and become horizontal;
No penalty for failing to label axes.

forward reaction:

highest concentration, thus rate high to begin with;
as reaction proceeds, concentrations decrease, so does rate;

reverse reaction:

zero rate initially/at $t = 0$ (since no products present);
rate increases as concentration of products increases;
equilibrium established when rate of forward reaction = rate of reverse reaction; 7

- (b) (reaction is) endothermic;
 K_c increases with (increasing) temperature;
forward reaction favoured/heat used up/OWTTE; 3

[10]

29. (i) $(K_c =) \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}$;

(horizontal line) concentration of reactant and product remains constant/equilibrium reached;

(magnitude of) K_c greater than 1;

Accept 1.6.

product concentration greater than reactant concentration; 4

- (ii) increased temperature shifts equilibrium position to right;
(forward) reaction is endothermic/absorbs heat; 2
- (iii) increased pressure shifts equilibrium to left;
fewer (gas) moles/molecules on left; 2
- (iv) both/forward and reverse rates increased/increase in forward reverse rates are equal;



activation energy reduced;
position of equilibrium unchanged;
concentration/amount of reactants and products remain constant;
value of K_c unchanged;
 K_c only affected by changes in temperature;

6

[14]

30. (a) $K/K_c = [\text{SO}_3]^2 \div [\text{SO}_2]^2 [\text{O}_2]$; 1
Accept correct K_p expression.

(b) (i) vanadium(V) oxide/(di)vanadium pentaoxide/ V_2O_5 ; 1
Allow just vanadium oxide but not correct formula.

(ii) catalyst does not affect the value of K_c ;
forward and reverse rates increase equally/by the same factor;
catalyst increases the rate of the reaction;
(by providing an alternative path for the reaction with) lower
activation energy; 4

(c) more energetic collisions/more molecules have energy greater than
activation energy;
more frequent collisions; 2

(d) (i) shifts equilibrium position to the products/right;
to the side with fewer gas molecules or moles/lower volume of gas; 2

(ii) shifts equilibrium position to the products/right;
to compensate for loss of SO_3 /produce more SO_3 ; 2

(iii) no effect;
forward and backward rates increased equally/by the same factor; 2

[14]

31. (a) $K / K_c = [\text{SO}_3]^2 \div [\text{SO}_2]^2 [\text{O}_2]$; 1
Exactly as written.
Accept correct K_p expression.

(b) (i) vanadium(V) oxide/(di)vanadium pentaoxide/ V_2O_5 /Pt; 1
Allow just vanadium oxide but not incorrect formula.

(ii) catalyst does not affect the value of K_c ;
forward and reverse rate increase equally/by the same factor;
catalyst increases the rate of the reaction;
(by providing an alternative path for the reaction with) lower
activation energy; 4

(c) (i) shifts equilibrium position to the products/right;
to the side with least gas molecules or moles/lower volume of gas; 2

(ii) shifts equilibrium position to the products/right;
to compensate for loss of SO_3 /produce more SO_3 ; 2

[10]



32. no effect on position of equilibrium;
forward and reverse reactions speeded up equally/affects the rate of reaction
but not the extent of the reaction;
no effect on value of K_c ;
no change in concentrations of reactants or products/ K_c only changes if
temperature alters; [4]
33. $k_c = \frac{[\text{H}_2]^3[\text{CO}]}{[\text{CH}_4][\text{H}_2\text{O}]}$; [1]
34. (a) (i) shifts to the right/toward products/forward reaction favoured;
to consume excess Br^- added; 2
Do not accept "due to Le Chatelier's principle".
- (ii) shifts to the left/toward reactants/reverse reaction favoured;
NaOH reacts to consume H^+ /an increase in the amount of H_2O
resulting from neutralization; 2
- (iii) no effect;
catalyst increases the rate of the forward and backward reactions
equally/lowers the activation energy of both forward and backward
reaction equally/lowers E_A so rate of forward and backward reactions
increase equally; 2
- (b) equilibrium constant decreases;
forward reaction is exothermic/produces heat/reverse reaction is endothermic
/absorbs heat; 2
- (c) colour change from red-brown to darker red-brown of Br_2 /red-brown colour
intensifies/OWTTE;
equilibrium position shifts to the right/products;
to consume H^+ ; 3 [11]
35. (i) $K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]}$; 1
- (ii) pressure
high pressure (will allow system to occupy smaller volume);
 $V_{\text{product}} < V_{\text{reactant}}$ /equilibrium moves to the right to reduce pressure
/reaction proceeds to lower/lowest number of gaseous molecules
/OWTTE;
Temperature
low temperature;
(exothermic reaction) forward reaction favoured to replace some
of the heat removed/equilibrium moves to the right to produce heat
/OWTTE; 4
No mark for just saying "due to Le Chatelier's principle"



- (iii) rate is faster at 450°C (than at low temperatures);
>95%/90 – 99% yield/(very) high conversion takes place;
unnecessary to use expensive high pressure equipment/(to achieve) high pressure is very expensive; 3
- (iv) vanadium pentoxide/vanadium(V) oxide/V₂O₅/finely divided platinum/Pt;
no effect on K_c ;
forward and reverse rates speeded up (equally); 3
- [11]
36. (i) $\text{CH}_4(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \rightleftharpoons 4\text{H}_2(\text{g}) + \text{CO}_2(\text{g})$;
States not required. Award [1] for balanced equation and [1] for equilibrium sign.
- $$K_c = \frac{[\text{H}_2]^4[\text{CO}_2]}{[\text{CH}_4][\text{H}_2\text{O}]^2};$$
- units: mol² dm⁻⁶/mol² L⁻²/mol² l⁻²; do not accept: M^2 4
- (ii) (endothermic reaction) increase in temperature (favours the forward reaction);
absorbs (some of) the heat supplied/OWTTE;
Award no marks for saying: "because of Le Chatelier's principle".
- low pressure (will allow system to occupy more volume);
 $V_{\text{product}} > V_{\text{reactant}}$ /reaction proceeds to greater number of gaseous moles /molecules/more moles of gases on right/OWTTE;
- ECF from (i)* 4
- (iii) at high pressure concentration increases/reaction rate faster;
more frequent collisions; 2
- [10]
37. less product is present at higher temperatures;
Therefore the forward reaction is exothermic; 2
- [2]
38. (i) $(K_c =) \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$ (*ignore units*); 1
- (ii) *Increasing the pressure:*
Yield increases/equilibrium moves to the right/more ammonia;
4 gas molecules → 2/decrease in volume/fewer gas molecules on right hand side;
- Increasing the temperature:*
Yield decreases/equilibrium moves to the left/less ammonia;
Exothermic reaction/OWTTE; 4



- (iii) Higher temperature increases rate;
Lower pressure is less expensive/lower cost of operating at low
pressure/reinforced pipes not needed; 2
Do not award a mark just for the word "compromise".
- (iv) 2.2 (dm³); 1
Penalize incorrect units.
- (v) Fertilizers/increasing crop yields;
Production of explosives for mining; 1
max
- (vi) Fe/iron; 2
Allow magnetite/iron oxide.
- Claim is not valid since catalysts do not alter the yield/position
of equilibrium/only increase the rate of reaction; 2

[11]