End of Year Review ANSWERS

1. Example of an appropriate and complete solution

$$\Delta H = \frac{-mc\Delta T}{\text{mol HCl}}$$

m = 70.0 g

c = 4.19 J/g°C

ΔT = 29.8°C − 22.4°C
= 7.4°C

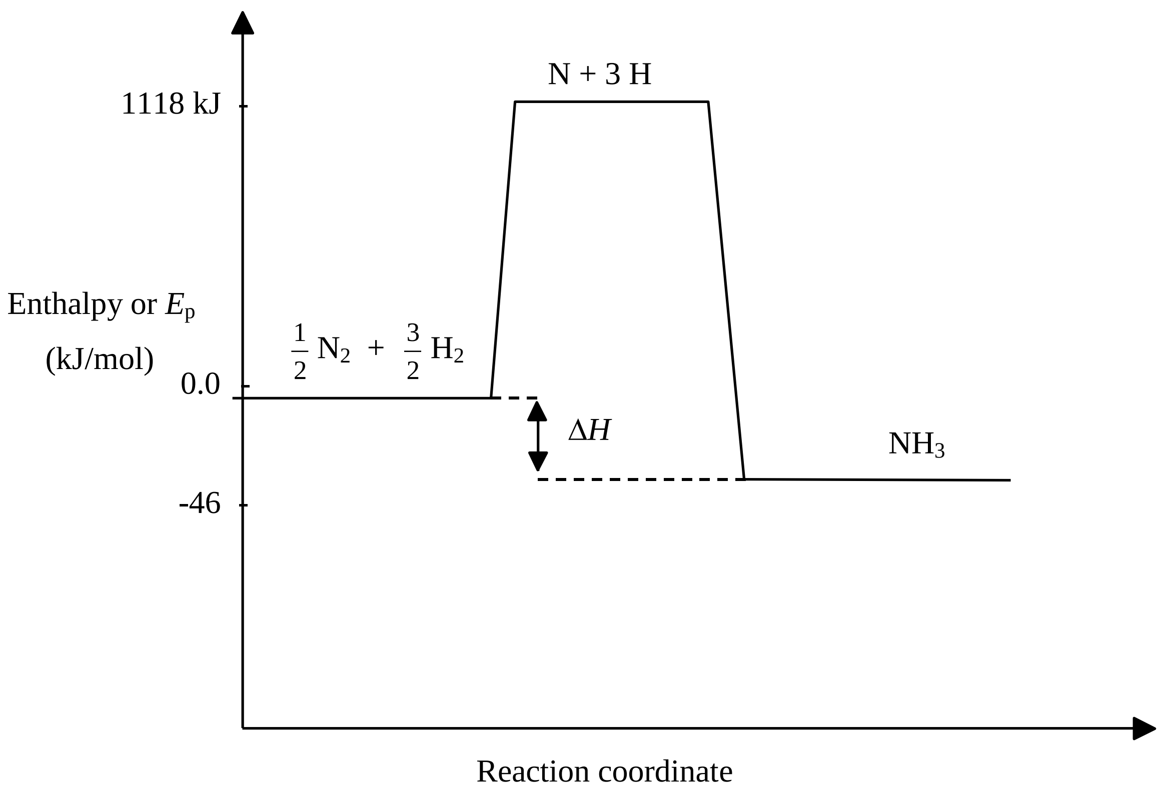
mol HCl = 3.00 mol/L × 0.0200 L
= 0.0600 mol

$$\Delta H = \frac{-(70.0\text{ g})(4.19\text{ J/g°C})(7.4\text{ °C})}{0.0600\text{ mol}}$$

= - 36 000 J/mol or - 36 kJ/mol

Answer: The molar heat of neutralization of $HCl_{(aq)}$ is **- 36 000 J/mol or - 36 kJ/mol.**

2. Examples of an appropriate and complete solution



Criteria:

1. y axis is labelled correctly, including units and values.

2. Correct ΔH.

3. Activation energy values are correctly indicated.

4. Reactants, activated complex, and products are correctly labelled.

Note: Students may use arrows to indicate the difference in energy levels rather than indicating numbers on the y axis.

3. Example of an appropriate procedure

1. Number of moles of $Mg_{(s)}$

   24.31 g of $Mg_{(s)}$ $\rightarrow$ 1 mol

   1.78×10^{-2} g of $Mg_{(s)}$ $\rightarrow$? $\dfrac{1\,\text{mol} \times 1.78 \times 10^{-2}\ \text{g}}{24.31\,\text{g}}$

   7.32×10^{-4} mol

2. Number of moles of $H_{2(g)}$

   According to the equation, the number of moles of $H_{2(g)}$ is equal to the number of moles of $Mg_{(s)}$. The number of moles of $H_{2(g)}$ is : 7.32×10^{-4} mol.

3. Volume of $H_{2(g)}$

   $PV = nRT$

   $101.3\ \text{kPa} \times V = 7.32 \times 10^{-4}\ \text{mol} \times \dfrac{8.31\,\text{kPa} \bullet \text{L}}{\text{mol} \bullet \text{K}} \times 298\ \text{K}$

   V = 0.01789 L (17.9 mL)

4. Average rate of production of $H_{2(g)}$

   $$\text{Average rate} = \frac{\text{Volume of } H_{2(g)} \text{ produced (mL)}}{\text{Duration of the reaction (s)}}$$

   $$\text{Average rate} = \frac{17.9\ \text{mL}}{400\ \text{s}} = 0.044\ 75\ \text{mL/s}$$

Answer

The average rate of production of H_2(g) is 4.48×10^{-2} mL/s.

4. a) rate = k $[NO_{(g)}]^2$ $[Br_{2(g)}]$
b) D

5. A

6, 7, 8, 9 – Answers on worksheet for partial pressures in End of Year Review

10. A

11. **Example of an appropriate and complete solution**

Initially, [HCl]

$10^{-1.00}$ mol/L = 0.100 mol/L

Number of moles of HCl

0.100 mol

At 25 s, [HCl]

$10^{-2.00}$ mol/L = 0.0100 mol/L

Number of moles of HCl

0.0100 mol

Number of moles of HCl used in 25 s

0.100 – 0.0100 = 0.090 mol

Moles of CO_2 produced

$$0.090 \text{ mol} \times \frac{1\,CO_2}{2\,HCl} = 0.045 \text{ mol } CO_2$$

Rate of formation of CO_2

$$\frac{0.045 \text{ mol}}{25 \text{ s}} = 0.0018 \text{ mol/s}$$

Answer: The average rate of formation of carbon dioxide gas was **0.0018 mol/s**.

Note: Accept the answer 0.079 g/s also.

12. Ksp = 1.1 x 10^{-12}

13. 1.67 x 10^{-2} $\frac{g\ CaF_2}{L}$

14. i) 3.87 x 10^{-5} $\frac{mol\ BaSO_4}{L}$

5.32 x 10^{-3} $\frac{g\ Ba^{2+}}{L}$

ii) 3.42 x 10^{-17} $\frac{mol\ Ag_2SO_4}{L}$

7.38 x 10^{-15} $\frac{g\ Ag^{+}}{L}$

15. a) $PbSO_4$ has the highest Ksp value which means that there is more product (in this case Pb^{2+} and SO_4^{2-}) at equilibrium then the other two salts.

b) 1.3 x 10^{-4} $\frac{mol\ PbSO_4}{L}$

16. a) $BaF_{2(s)} \leftrightarrow Ba^{2+}_{(aq)} + 2\ F^{-}_{(aq)}$

b) According to the graph, $[Ba^{2+}]$ = 1.8×10^{-2} mol/L

or

according to the solubility, $[Ba^{2+}]$ = 3.15 g/L

$$n = \frac{m}{M} = \frac{3.15}{175} = 1.8 \times 10^{-2} \text{ mol/L}$$

K_{sp} = $[Ba^{2+}] \bullet [F^{-}]^2$, $[F^{-}] = 2\ [Ba^{2+}]$

= $(1.8 \times 10^{-2} \text{ mol/L}) \bullet (3.6 \times 10^{-2} \text{ mol/L})^2$

K_{sp} = 2.33×10^{-5}

Answer : The solubility product constant of this salt is 2.33×10^{-5}.

17. Example of an appropriate explanation

Given the equation $H_{2(g)} + I_{2(g)} \leftrightarrow 2HI_{(g)}$ + 11 kJ, the mathematical expression for the constant, K_{eq}, is :

$$K_{eq} = \frac{[HI_{(g)}]^2}{[H_{2(g)}][I_{2(g)}]}$$

A temperature increase favours the reverse reaction because the forward reaction is exothermic.

As a result, the concentration of the reactants will increase and the concentration of the product will decrease.

The value of the denominator will therefore increase and that of the numerator will decrease. Consequently, the value of the constant,, K_{eq}, will decrease.

Answer

The value of the equilibrium constant for this system will decrease.

18. Example of an appropriate explanation

- Adding $NaOH_{(s)}$ to the solution releases $OH^{-}_{(aq)}$ ions. These ions react with $H^{+}_{(aq)}$ ions to form $H_2O_{(l)}$. Consequently, the concentration of $H^{+}_{(aq)}$ ions decreases.

- If the concentration of $H^{+}_{(aq)}$ decreases, the system reacts so as to restore equilibrium. According to Le Chatelier's principle, the reaction shifts towards the left.

Answer

The concentration of $Mg_{(s)}$ does not change.
The concentration of $H^{+}_{(aq)}$ decreases.
The concentration of $H_{2(g)}$ decreases.
The concentration of $Mg^{2+}_{(aq)}$ decreases.

19. Example of an appropriate procedure

	H_2	+	I_2	$\leftrightarrow$	2 HI	
I :	x		8		-----	
C :	3		3		-----	} number of moles
E :	x - 0.03		5		6	

Volume = 3 L
Concentration [HI] = 0.02 mol/L

$$K = \frac{[HI]^2}{[H_2][I_2]}$$

K = 26.3

$$26.3 = \frac{(0.02)^2}{(x/3 - 0.01) \times (0.0167)}$$

x = 0.0327 mole

Answer : Initial number of moles $H_{2(g)}$ in the balloon was 0.0327 mol.

20. Example of an appropriate and complete procedure

$$K_{HA} = \frac{[H^+] \bullet [A^-]}{[HA]} = \frac{(1 \times 10^{-4}\ \text{mol/L}) \times (1 \times 10^{-4}\ \text{mol/L})}{(5 \times 10^{-8}\ \text{mol/L})} = 0.2$$

$$K_{HB} = \frac{[H^+] \bullet [B^-]}{[HB]} = \frac{(1 \times 10^{-8}\ \text{mol/L}) \times (1 \times 10^{-8}\ \text{mol/L})}{(1 \times 10^{-4}\ \text{mol/L})} = 1 \times 10^{-12}$$

Answer: HA is the strongest acid because it has the highest K_a value.

21. a) Increasing the total pressure : The mole ratio of gases in the reactant to gases in the product is 4 : 2 or 2 :1. The greater number of moles on the reactant side creates a greater number of collisions as the pressure is increased. This favours the products.

Therefore, the concentration of NH_3 will **increase.**

b) Increasing the temperature : The forward reaction is exothermic. The increase in temperature creates a stress on the equilibrium system which it alleviates by using up (absorbing) the added heat energy. This favours the endothermic direction. As a result, the reactants are favoured.

Therefore, the concentration of NH_3 will **decrease.**

c) Increasing the volume of the container : Since all the reactants and products are gases, increasing the volume will decrease the total pressure (according to Boyle's law). This has the reverse effect of the result in part a). This favours the reactants. Shifts to side with more moles.

Therefore, the concentration of NH_3 will **decrease.**

d) Adding an appropriate catalyst : The catalyst will lower the activation energy for the reaction, thereby affecting both the forward and reverse reactions to the same degree. This does not affect the equilibrium and neither the products nor reactants are favoured.

Therefore, the concentration of NH_3 remains **unchanged**.

e) Increasing the concentration of N_2 : The increased concentration of N_2 will create a greater number of collisions between reactants. This will accelerate the rate of the forward reaction and favour the products.

Therefore, the concentration of NH_3 will **increase.**

22. D

23. Example of an appropriate and complete answer

	$4\ NH_{3(g)}$	+ $3\ O_{2(g)}$	$\leftrightarrow$	$2\ N_{2(g)}$	$+\ 6\ H_2O_{(g)}$
I	0.0150	0.0150		0	0
C	-3.92×10^{-3}	-2.94×10^{-3}		$+1.96 \times 10^{-3}$	$+5.88 \times 10^{-3}$
E	1.11×10^{-2}	1.21×10^{-2}		$+1.96 \times 10^{-3}$	$+5.88 \times 10^{-3}$

$$K_c = \frac{[N_2]^2\,[H_2O]^6}{[NH_3]^4\,[O_2]^3}$$

$$= \frac{[1.96 \times 10^{-3}\ \text{mol/L}]^2\,[5.88 \times 10^{-3}\ \text{mol/L}]^6}{[1.11 \times 10^{-2}\ \text{mol/L}_3]^4\,[1.21 \times 10^{-2}\ \text{mol/L}]^3}$$

$$= 6.01 \times 10^{-6}$$

Answer: The K_c for the reaction at this temperature is $\mathbf{6.01 \times 10^{-6}}$.

24. B

25. Example of an appropriate and complete solution

Butanoic Acid

	HA	$\leftrightarrow$	H^+	+ A^-
I	0.15		0	0
C	-1.51×10^{-3}		1.51×10^{-3}	+ 1.51×10^{-3}
E	0.148		1.51×10^{-3}	1.51×10^{-3}

$$K_a = \frac{\left[1.51 \times 10^{-3} \text{ mol/L}\right]^2}{0.148 \text{ mol/L}}$$

$$= \mathbf{1.54 \times 10^{-5}}$$

Hydrofluoric Acid

First find $[H^+]$

$$\frac{K_W}{7.59 \times 10^{-10}} = 1.32 \times 10^{-5}$$

	HA	$\leftrightarrow$	H^+	+ A^-
I	0.035		0	0
C	-1.32×10^{-5}		1.32×10^{-5}	+ 1.32×10^{-5}
E	0.035		1.32×10^{-5}	1.32×10^{-5}

$$K_a = \frac{\left[1.32 \times 10^{-5} \text{ mol/L}\right]^2}{0.0350 \text{ mol/L}}$$

$$= \mathbf{4.98 \times 10^{-9}}$$

Answer: **Butanoic acid** is the stronger of the two.

Note: Comparing percent ionization is an acceptable justification.

26. A

27. Example of an appropriate process

1. Molar heat of combustion of $C_3H_{8\,(g)}$

$\Delta H = H_p - H_r$

$\Delta H = -2046 \text{ kJ/mol} - 0 \text{ kJ/mol}$

ΔH = -2046 kJ/mol

2. Apply Hess= law

$3\ CO_{2\ (g)} + 4\ H_2O_{(g)} \rightarrow C_3H_{8\ (g)} + 5\ O_{2\ (g)}$ ΔH = +2046 kJ
$4\ C_{(s)} + 3\ O_{2\ (g)} \rightarrow 3\ CO_{2\ (g)}$ ΔH = -1182 kJ
$4\ H_{2\ (g)} + 2\ O_{2\ (g)} \rightarrow 4\ H_2O_{(g)}$ ΔH = -968 kJ

Add the three equations

$3\ C_{(s)} + 4\ H_{2\ (g)} \rightarrow C_3H_{8\ (g)}$ ΔH = -104 kJ

Answer

The molar heat of formation of propane gas is -104 kJ/mol.