End of Year Review

1. When a calorimeter was filled with 20.0 mL of 3.00 mol/L hydrochloric acid, $HCl_{(aq)}$, and 50.0 mL of 1.20 mol/L sodium hydroxide, $NaOH_{(aq)}$, the temperature rose from 22.4°C to 29.8°C.

What was the molar heat of neutralization of $HCl_{(aq)}$?
(Assume the density and specific heat for all solutions to be equal to that of water.)

2. The Haber process for the formation of ammonia (NH_3)) from the elements can be derived from the following equations:

$$\frac{1}{2}\ N_{2(g)} + \frac{3}{2}\ H_{2(g)} \rightarrow N_{(g)} + 3\ H_{(g)} \quad E_{activation} = 1118\ \text{kJ}$$

$$NH_{3(g)} \rightarrow N_{(g)} + 3\ H_{(g)} \quad E_{activation} = 1164\ \text{kJ}$$

The Haber process can be written as $\frac{1}{2}\ N_{2(g)} + \frac{3}{2}\ H_{2(g)} \rightarrow NH_{3(g)}$

$N_{(g)} + 3\ H_{(g)}$ has been determined to be the activated complex for the overall reaction.

Draw an Enthalpy diagram to determine the ΔH for the Haber process. Indicate the ΔH on the diagram. The graph must indicate reactants, products, activated complex, ΔH, and appropriate values.

3. While studying the rate of various chemical reactions, a student measured the rate at which certain metals react with different acids. One of the experiments involved combining a strip of solid magnesium, $Mg_{(s)}$, with a hydrochloric acid solution, $HCl_{(aq)}$. The student made the following observations :

Mass of the magnesium strip used	1.78×10^{-2} g
Atmospheric pressure in the room	101.3 kPa
Room temperature	25.0°C
Temperature of the acidic solution	25.0°C
Duration of the reaction	6 min 40 s

This chemical reaction is represented by the following equation :

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$$

Under these conditions, what is the average rate of production of $H_{2(g)}$?

Note : Express this rate in millilitres of $H_{2(g)}$ produced per second (mL/s)

4. Consider the following chemical reaction:

$$2\ NO_{(g)} + Br_{2(g)} \rightarrow 2\ NOBr_{(g)}$$

a) Write the rate law for the reaction.

b) If the concentration of NO is tripled and that of Br_2 is doubled, by what factor will the initial rate of the reaction increase?

A)	3 times	C)	9 times
B)	6 times	D)	18 times

5. A student would like to carry out a reaction between sodium (Na) and water. Aware of the potential dangers of sodium, the student wants to control the rate of this reaction.

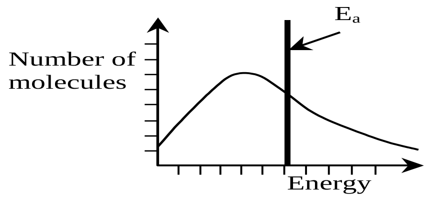
Which of the following would produce the slowest reaction between sodium and water?

1. Add sodium to water at 10°C.
2. Add sodium to water at 30°C.
3. Use a 2.0 g chunk of sodium.
4. Use 2.0 g of sodium cut into pieces.

A)	1 and 3	C)	2 and 3
B)	1 and 4	D)	2 and 4

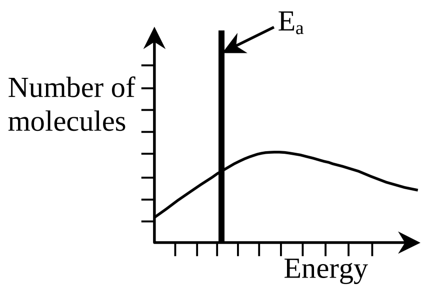
6,7,8,9 – Questions for partial pressures are a separate attachment on site. Could not be copied and pasted.

10. Study the kinetic energy distribution curve below:

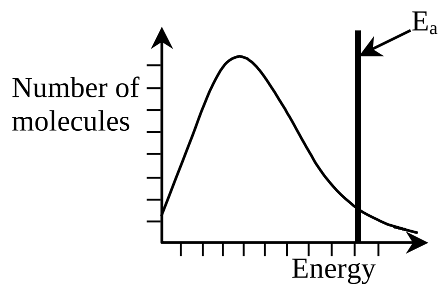


Which of the following energy distribution curves represents the effect of adding a catalyst and increasing temperature?

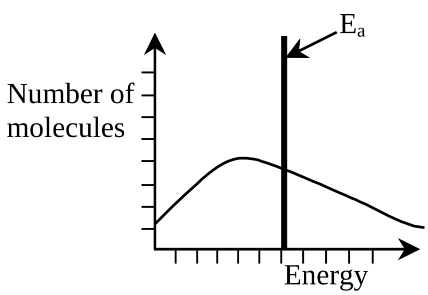
A)



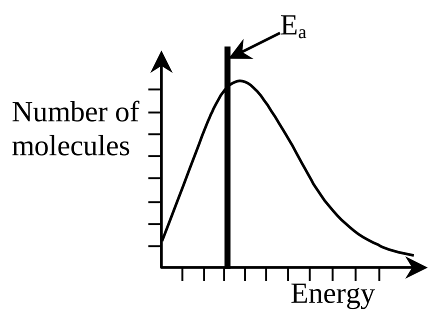
C)



B)



D)



11. A student neutralizes 1.00 L of hydrochloric acid, HCl, by adding calcium carbonate, $CaCO_3$.

The following reaction takes place:

$$2\ HCl_{(aq)} + CaCO_{3(s)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

The student uses a pH meter to check the progress of the reaction. It takes 25 seconds for the pH of the solution to change from 1.00 to 2.00.

What was the average rate of formation of carbon dioxide gas, CO_2, during this time?

12. Solid silver chromate is added to pure water at 25°C. Some of the solid remains undissolved $Ag_2CrO4(s)$ at the bottom of the flask. The mixture is stirred for several days to ensure that equilibrium is achieved between the undissolved and the solution. Analysis of the equilibrated solution shows that its silver ion concentration is $1.3\ X10^{-4}$ moles/L. Assuming that Ag_2CrO_4 dissociates completely in water and that there are no other important equilibria involving the Ag^+ or $CrO4^{-2}$ ions in the solution, calculate Ksp for this compound.

13. The Ksp for CaF_2 is 3.9×10^{-11} at 25 °C. Assuming that CaF_2 dissociates completely upon dissolving and that there are no other important equilibria affecting its solubility, calculate the solubility of CaF_2 in grams per liter.

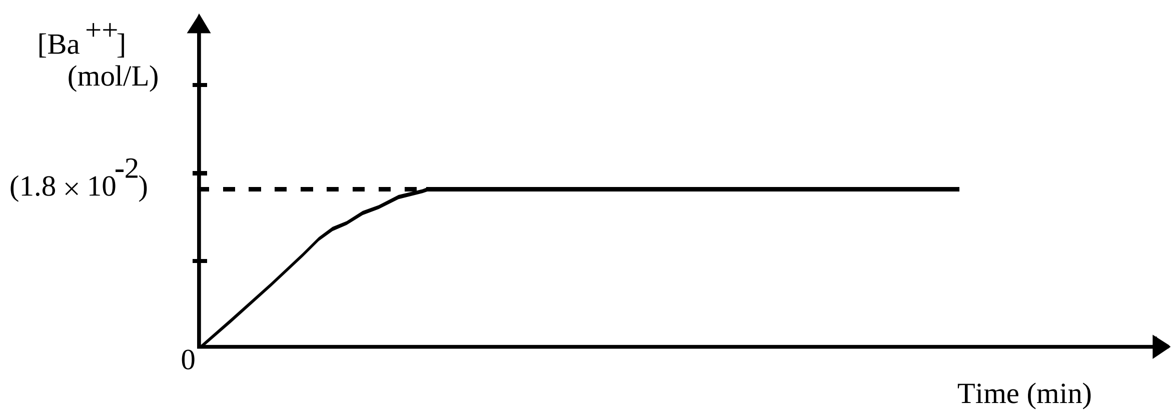
14. Consider these slightly soluble salts:
i) $BaSO_4$ Ksp = 1.5×10^{-9}
ii) Ag_2S Ksp = 1.6×10^{-49}
Calculate:
a) the solubility in moles/L
b) the concentration of the cations in g/L.

15. Consider these slightly soluble salts:
i) PbS Ksp = 8.4×10^{-28}
ii) $PbSO_4$ Ksp = 1.8×10^{-8}
iii) $Pb(IO_3)_2$ Ksp = 2.6×10^{-13}

a) Which is the most soluble?
b) Calculate the solubility in moles/L for $PbSO_4$.

16. Knowing that the solubility of (BaF_2) is 3.15 g/L at 25°C, a student puts 5 g of this substance into one litre of water. The graph below represents the concentration of Ba^{2+} ions as a function of time at 25°C.

Concentration of Ba^{++} ions as a Function of Time



a) Write the dissolution reaction.
b) Calculate the solubility product constant (Ksp) of this salt at 25°C.

17.The following equation represents the formation of hydrogen iodide, $HI_{(g)}$, from its elements :

$$H_{2(g)} + I_{2(g)} \leftrightarrow 2\ HI_{(g)} + 11\ kJ$$

How will a temperature increase affect the value of the equilibrium constant for this system?

Explain your answer.

18. Equilibrium is achieved in a closed system where metallic magnesium can react with hydrochloric acid. This system is represented by the following net ionic equation :

$$Mg_{(s)} + 2H^{+}_{(aq)} \quad \leftrightarrow \quad Mg^{2+}_{(aq)} + H_{2(g)}$$

A sodium hydroxide pellet, $NaOH_{(s)}$, is added to this system.

What happens to the concentration of each substance in the system?

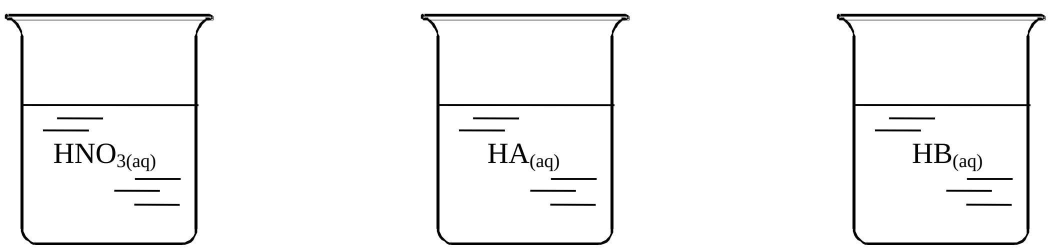
Explain your answer.

(This explanation must be based on Le Chatelier's principle.)

19. At 900 K, the equilibrium constant for $H_{2(g)} + I_{2(g)} \leftrightarrow 2\ HI_{(g)}$ is 26.3. A 3 L balloon containing hydrogen is injected with 0.0800 moles of iodine. When equilibrium is reached, the concentration of HI is 0.0200 mol/L.

How many moles of hydrogen were initially present in the balloon?

20. Three acids at equilibrium are shown in the diagram below.



$K_a = 5.1 \times 10^{-2}$

$[HA] = 5 \times 10^{-8}$ mol/L
$[H^{+}] = 1 \times 10^{-4}$ mol/L
K_a = ?

$[HB] = 1 \times 10^{-4}$ mol/L
pH = 8
$[H^{+}]$ = ?
K_a = ?

Based on the given information, which of the acids is the strongest?

21. Apply Le Chatelier's Principle to the following equilibrium system.

$$N_{2(g)} + 3\ H_{2(g)}) \leftrightarrow 2\ NH_{3(g)} + 80\ kJ/mol$$

What effect will each of the following changes have on the concentration of ammonia, $NH_{3(g)}$?

State **one reason** that justifies each answer.

a) increasing the total pressure
b) increasing the temperature
c) increasing the volume of the container
d) adding an appropriate catalyst
e) increasing the concentration of $N_{2(g)}$

22. The ionization constant (K_w) of water is 1×10^{-14} at 25°C.

$$H_2O + \text{energy} \leftrightarrow H^+ + OH^-$$

If the temperature of the water is increased to 50°C, which of the following will occur?

A) The K_w is unaffected by temperature and remains 1×10^{-14}.

B) K_w is a constant that does not change.

C) There will be a shift to re-establish equilibrium and K_w will decrease.

D) There will be a shift to re-establish equilibrium and K_w will increase.

23. When 0.0150 mol $NH_{3(g)}$ and 0.0150 mol $O_{2(g)}$ are introduced into a 1.00 L container at a certain temperature, the N_2 concentration at equilibrium is 1.96×10^{-3} mol/L.

$$4\ NH_{3(g)} + 3\ O_{2(g)} \leftrightarrow 2\ N_{2(g)} + 6\ H_2O_{(g)}$$

Calculate K_c for the reaction at this temperature.

24. The equilibrium constant (K_c) for the following reaction is 1.47×10^3.

$$H_3O^+_{(aq)} + F^-_{(aq)} \leftrightarrow HF_{(aq)} + H_2O_{(l)}$$

At equilibrium, which of the following statements about the reaction is true?

A) The concentration of H_3O^+ and F^- would be much larger than HF.

B) The concentration of HF would be much larger than H_3O^+ and F^-.

C) The concentration of H_3O^+ , F^- and HF would be approximately equal.

D) K_c has no effect on concentration.

25. A 0.15 mol/L solution of butanoic acid ($CH_3CH_2CH_2COOH$) has a H_3O^+ concentration of 1.51×10^{-3} mol/L. A 0.035 mol/L solution of hydrofluoric acid (HF) has an OH^- concentration of 7.59×10^{-10} mol/L.

Which of the two acids is stronger?

Justify your answer using appropriate calculations.

26. Examine the following decomposition reactions.

$$Al_2O_{3(s)} \rightarrow 2\ Al_{(s)} + \frac{3}{2}\ O_{2(g)} \qquad \Delta H = +\ 1676\ \frac{kJ}{mol}$$

$$H_2O_{(g)} \rightarrow H_{2(g)} + \frac{1}{2}\ O_{2(g)} \qquad \Delta H = +\ 242\ \frac{kJ}{mol}$$

What is the correct energy change associated with the following reaction in terms of $\frac{kJ}{mol\ Al}$?

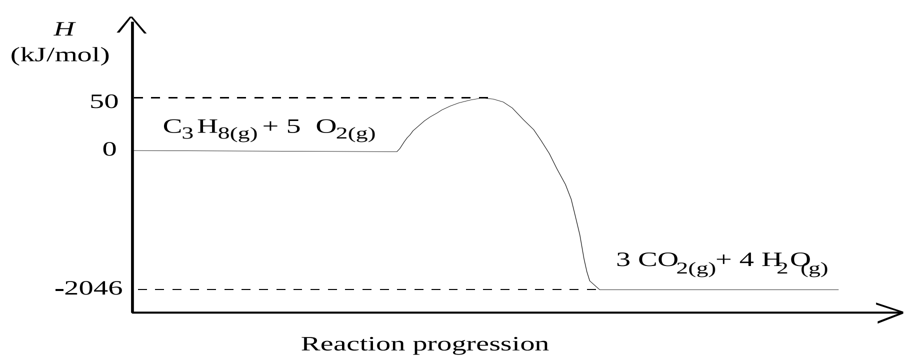
$$Al_2O_{3(s)} + 3\ H_{2(g)} \rightarrow 2\ Al_{(s)} + 3\ H_2O_{(g)} \qquad \Delta H = ?$$

A) $+\ 475\ \frac{kJ}{mol\ Al}$ B) $+\ 950\ \frac{kJ}{mol\ Al}$ C) $+\ 1434\ \frac{kJ}{mol\ Al}$ D) $+\ 2402\ \frac{kJ}{mol\ Al}$

27. The formation of propane gas, $C_3H_{8(g)}$, from its elements is represented by the following chemical equation :

$$3\ C_{(s)} + 4\ H_{2(g)} \rightarrow C_3H_{8(g)}$$

A scientist conducted an experiment at a certain temperature to determine the molar heat of formation of propane gas. The following diagram shows the test results, where the zero value has been arbitrarily assigned.



The scientist found the following information in a handbook.

$$H_2O_{(g)} + 242\ kJ \rightarrow H_{2(g)} + \frac{1}{2} O_{2(g)}$$

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} + 394\ kJ$$

Given this data, what is the molar heat of formation of propane gas?