Heat and Equilibrium After School Regents Review Practice

1. Given samples of water:
   Sample 1: 100. grams of water at 10.°C
   Sample 2: 100. grams of water at 20.°C

   Compared to sample 1, sample 2 contains

   A) molecules with a lower average kinetic energy
   B) molecules with a lower average velocity
   C) less heat energy
   D) more heat energy

2. Which form of energy is associated with the random motion of particles in a gas?

   A) chemical B) electrical
   C) nuclear **D) thermal**

3. A 10.0-gram sample of $H_2O(\ell)$ at 23.0°C absorbs 209 joules of heat. What is the final temperature of the $H_2O(\ell)$ sample?

   A) 5.0°C B) 18.0°C
   C) 28.0°C D) 50.0°C

4. Given the balanced equation representing a reaction:

   $$2H_2O(\ell) + 571.6\text{kJ} \rightarrow 2H_2(g) + O_2(g)$$

   What occurred as a result of this reaction?

   A) Energy was absorbed, and entropy increased.
   B) Energy was absorbed, and entropy decreased.
   C) Energy was released, and entropy increased.
   D) Energy was released, and entropy decreased.

5. At 101.3 kPa and 298 K, what is the total amount of heat released when one mole of aluminum oxide, $Al_2O_3(s)$, is formed from its elements?

   A) 393.5 kJ B) 837.8 kJ
   C) 1676 kJ D) 3351 kJ

6. In a laboratory where the air temperature is 22°C, a steel cylinder at 100.°C is submerged in a sample of water at 40.°C. In this system, heat flows from

   A) both the air and the water to the cylinder
   B) both the cylinder and the air to the water
   C) the air to the water and from the water to the cylinder
   D) the cylinder to the water and from the water to the air

7. Which temperature represents the highest average kinetic energy of the particles in a sample of matter?

   A) 298 K B) 267 K
   C) 27°C D) 12°C

8. The average kinetic energy of water molecules increases when

   A) $H_2O(s)$ changes to $H_2O(\ell)$ at 0ºC
   B) $H_2O(\ell)$ changes to $H_2O(s)$ at 0ºC
   C) $H_2O(\ell)$ at 10ºC changes to $H_2O(\ell)$ at 20ºC
   D) $H_2O(\ell)$ at 20ºC changes to $H_2O(\ell)$ at 10ºC

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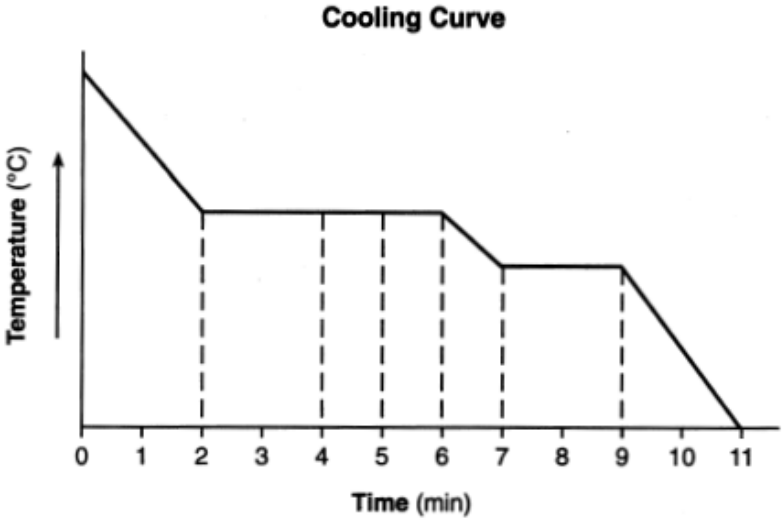
9. The cooling curve below represents the uniform cooling of a substance, starting at a temperature above its boiling point.



During which time interval does the substance exist as both a liquid and a solid?

A) min 2 to min 4 B) min 4 to min 5 C) min 5 to min 7 **D) min 7 to min 9**

10. At standard pressure, during which physical change does the potential energy decrease?

A) liquid to gas **B) liquid to solid**
C) solid to gas D) solid to liquid

11. What is the total amount of heat required to vaporize 1.00 gram of $H_2O(\ell)$ at 100.°C and 1 atmosphere?

A) 4.18 J B) 334 J
C) 373 J **D) 2260 J**

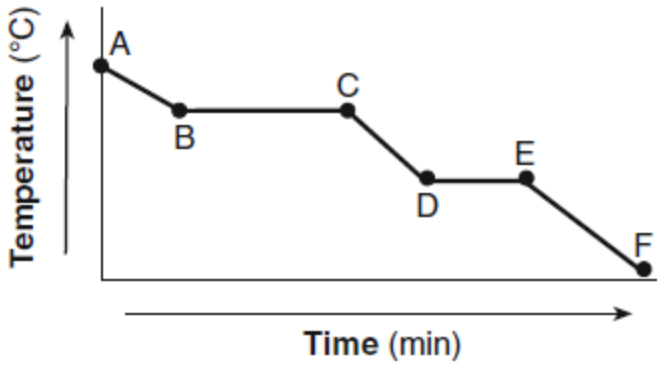
12. Systems in nature tend to undergo changes toward

A) lower energy and lower entropy
B) lower energy and higher entropy
C) higher energy and lower entropy
D) higher energy and higher entropy

13. Which 1.0-mole sample at 1 atm has particles with the greatest entropy?

A) $CH_4(g)$ at 25ºC **B) $H_2S(g)$ at 40ºC**
C) $CH_4(g)$ at 300 K D) $H_2S(g)$ at 310 K

14. Given the cooling curve of a substance:



During which intervals is potential energy decreasing and average kinetic energy remaining constant?

A) *AB* and *BC* B) *AB* and *CD*
C) *DE* and *BC* D) *DE* and *EF*

15. As a 15.1-gram sample of a metal absorbs 48.75 J of heat, its temperature increases 25.0K. What is the specific heat capacity of the metal?

A) 0.129 J/g°K B) 1.95 J/g°K
C) 3.23 J/g°K D) 7.74 J/g°K

16. What is the amount of heat required to completely melt a 200.-gram sample of $H_2O(s)$ at STP?

    A) 334 J B) 836 J
    C) 66800 J D) 452000 J

17. Which element has a melting point higher than the melting point of rhenium?

    A) iridium B) osmium
    C) tantalum **D) tungsten**

18. Which mathematical expression represents the heat of reaction for a chemical reaction?

    A) (the heat of fusion) – (the heat of vaporization)
    B) (the heat of vaporization) – (the heat of fusion)
    C) (the potential energy of the products) – (the potential energy of the reactants)
    D) (the potential energy of the reactants) – (the potential energy of the products)

19. A gas changes directly to a solid during

    A) fusion **B) deposition**
    C) saponification D) decomposition

20. Which sample of matter sublimes at room temperature and standard pressure?

    A) $Br_2(\ell)$ B) $Cl_2(g)$
    C) $CO_2(s)$ D) $SO_2(aq)$

21. At standard pressure, CH_4 boils at 112 K and H_2O boils at 373 K. What accounts for the higher boiling point of H_2O at standard pressure?

    A) covalent bonding
    B) ionic bonding
    C) hydrogen bonding
    D) metallic bonding

22. Which statement explains why Br_2 is a liquid at STP and I_2 is a solid at STP?

    A) Molecules of Br_2 are polar, and molecules of I_2 are nonpolar.
    B) Molecules of I_2 are polar, and molecules of Br_2 are nonpolar.
    C) Molecules of Br_2 have stronger intermolecular forces than molecules of I_2 .
    D) Molecules of I_2 have stronger intermolecular forces than molecules of Br_2 .

23. Base your answer to the following question on the information below and on your knowledge of chemistry.

The table below contains selected information about chlorine and two compounds containing chlorine. One piece of information is missing for each of the substances in the table.

Chlorine and Two Compounds Containing Chlorine

Name	Formula	Molar Mass (g/mol)	Phase at STP
chlorine	Cl_2	71	?
calcium chloride	$CaCl_2$	?	solid
1,2-dichloroethene	?	97	liquid

Identify the phase of the chlorine at STP.

24. Base your answer to the following question on the information below and on your knowledge of chemistry.

At standard pressure, water has unusual properties that are due to both its molecular structure and intermolecular forces. For example, although most liquids contract when they freeze, water expands, making ice less dense than liquid water. Water has a much higher boiling point than most other molecular compounds having a similar gram-formula mass.

Explain why $H_2O(s)$ floats on $H_2O(\ell)$ when both are at 0°C.

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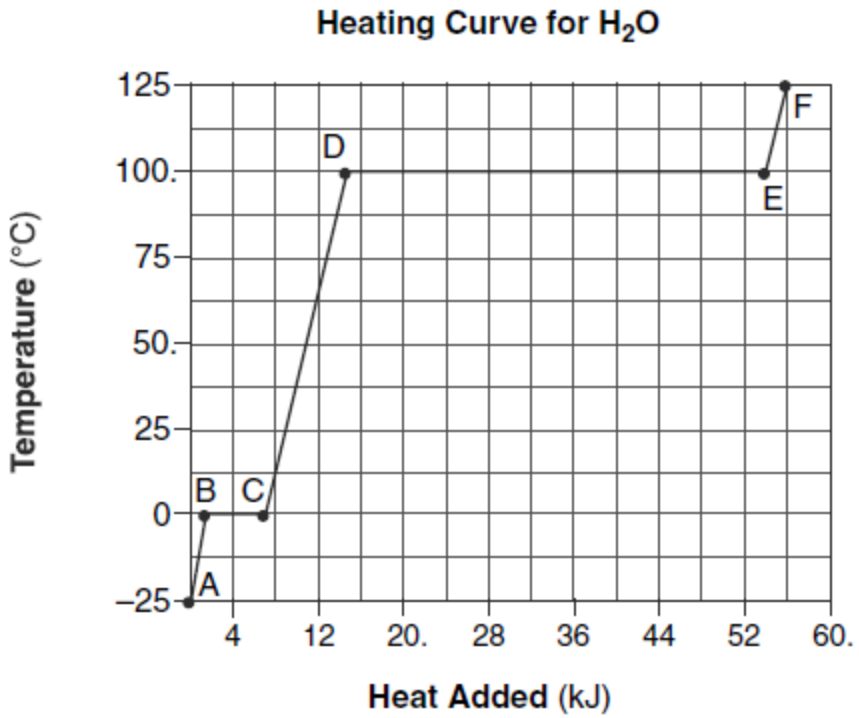
Base your answers to questions **25** through **27** on the information below and on your knowledge of chemistry.

Starting as a solid at –25°C, a sample of H_2O is heated at a constant rate until the sample is at 125°C. This heating occurs at standard pressure. The graph below represents the relationship between temperature and heat added to the sample.



25. Explain, in terms of heat of fusion and heat of vaporization, why the heat added during interval *DE* is greater than the heat added during interval *BC* for this sample of water.

26. Using the graph, determine the total amount of heat added to the sample during interval *CD*.

27. Describe what happens to both the potential energy and the average kinetic energy of the molecules in the H_2O sample during interval *AB*.

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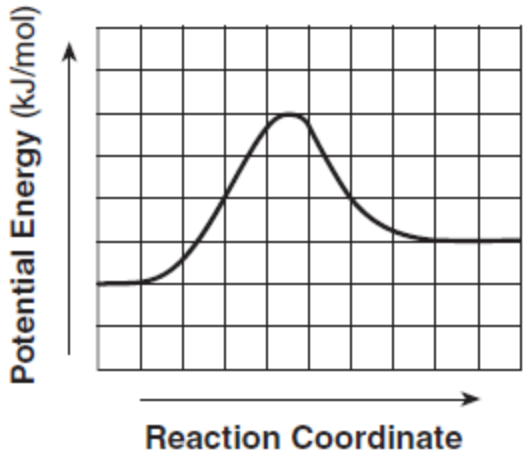
28. A chemical reaction is most likely to occur when the colliding particles have the proper

    A) energy and orientation
    B) solubility and density
    C) ionic radii and mass
    D) atomic radii and volume

29. Given the potential energy diagram for a reversible chemical reaction:



Each interval on the axis labeled "Potential Energy (kJ/mol)" represents 10. kilojoules per mole. What is the activation energy of the forward reaction?

A) 10. kJ/mol B) 30. kJ/mol
C) 40. kJ/mol D) 60. kJ/mol

30. For a reaction at equilibrium, which change can increase the rates of the forward and reverse reactions?

A) a decrease in the concentration of the reactants
B) a decrease in the surface area of the products
C) an increase in the temperature of the system
D) an increase in the activation energy of the forward reaction

31. At 101.3 kPa and 298 K, a 1.0-mole sample of which compound absorbs the greatest amount of heat as the entire sample dissolves in water?

A) LiBr B) NaCl
C) NaOH **D) NH_4Cl**

32. Given the balanced equation representing a reaction:
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + \text{energy}$

Which change in reaction conditions will increase the frequency of effective collisions between reactant molecules?

A) decreasing the pressure of the reactants
B) decreasing the temperature of the reactants
C) increasing the concentration of the reactants
D) increasing the volume of the reactants

33. In the laboratory, a student investigates the effect of concentration on the reaction between HCl(aq) and Mg(s), changing only the concentration of HCl(aq). Data for two trials in the investigation are shown in the table below.

Data Table

Trial	Volume of HCl(aq) (mL)	Concentration of HCl(aq) (M)	Mass of Mg(s) (g)	Reaction Time (s)
1	50.0	0.2	0.1	48
2	50.0	0.4	0.1	?

Compared to trial 1, what is the expected reaction time for trial 2 and the explanation for the result?

A) less than 48 s, because there are fewer effective particle collisions per second
B) less than 48 s, because there are more effective particle collisions per second
C) more than 48 s, because there are fewer effective particle collisions per second
D) more than 48 s, because there are more effective particle collisions per second

34. Given the balanced equation representing a reaction:

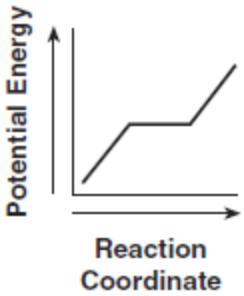
$$Fe(s) + 2HCl(aq) \rightarrow FeCl_2\,(aq) + H_2(g)$$

This reaction occurs more quickly when powdered iron is used instead of a single piece of iron of the same mass because the powdered iron

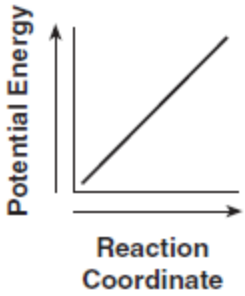
A) acts as a better catalyst than the single piece of iron
B) absorbs less energy than the single piece of iron
C) has a greater surface area than the single piece of iron
D) is more metallic than the single piece of iron

35. Which diagram represents the potential energy changes during an exothermic reaction?

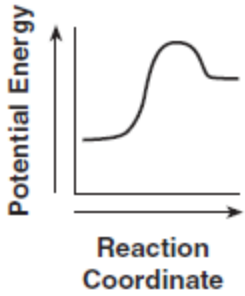
A)



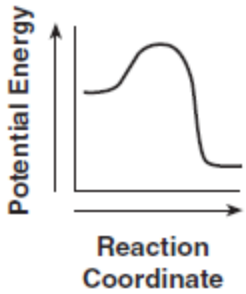
B)



C)



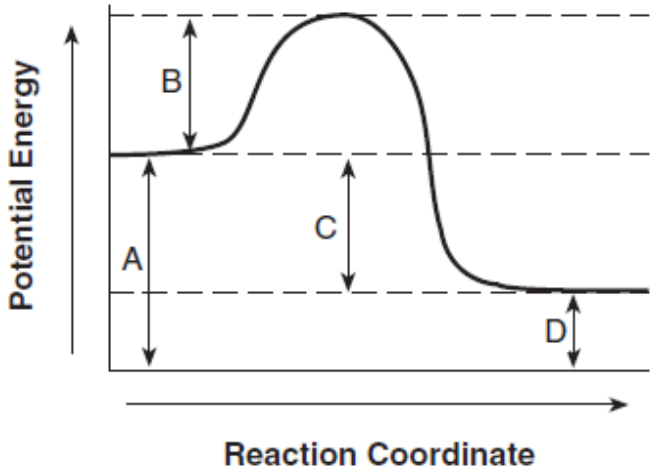
D)



36. Which compound is formed from its elements by an exothermic reaction at 298 K and 101.3 kPa?

A) $C_2H_4(g)$ B) $HI(g)$
C) $H_2O(g)$ D) $NO_2(g)$

37. Given the potential energy diagram representing a reversible reaction:

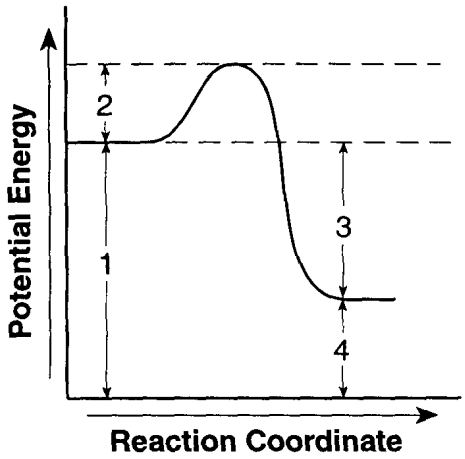


The activation energy for the reverse reaction is represented by

A) $A + B$ **B) $B + C$**
C) $B + D$ D) $C + D$

38. Base your answer to the following question on the potential energy diagram below, which represents the reaction:

$A + B \rightarrow C +$ energy.



Which numbered interval will change with the addition of a catalyst to the system?

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

39. Which equation represents a chemical equilibrium?

A) $N_2(\ell) \rightleftharpoons N_2(g)$
B) $2NO_2(g) \rightleftharpoons N_2O_4(g)$
C) $CO_2(s) \rightleftharpoons CO_2(g)$
D) $NH_3(\ell) \rightleftharpoons NH_3(g)$

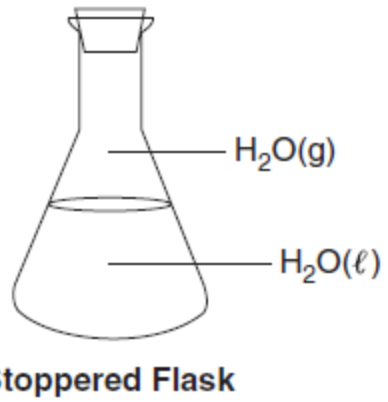
40. Which statement best explains the role of a catalyst in a chemical reaction?

A) A catalyst is added as an additional reactant and is consumed but not regenerated.
B) A catalyst limits the amount of reactants used.
C) A catalyst changes the kinds of products produced.
D) A catalyst provides an alternate reaction pathway that requires less activation energy.

41. Given the equation representing a chemical reaction at equilibrium in a sealed rigid container:
$H_2(g) + I_2(g) + \text{energy} \rightleftharpoons 2HI(g)$
When the concentration of $H_2(g)$ is increased by adding more hydrogen gas to the container at constant temperature, the equilibrium shifts

A) to the right, and the concentration of HI(g) decreases
B) to the right, and the concentration of HI(g) increases
C) to the left, and the concentration of HI(g) decreases
D) to the left, and the concentration of HI(g) increases

42. Given the diagram representing a closed system at constant temperature:



Which statement describes this system at equilibrium?

A) The mass of $H_2O(\ell)$ equals the mass of $H_2O(g)$.
B) The volume of $H_2O(\ell)$ equals the volume of $H_2O(g)$.
C) The number of moles of $H_2O(\ell)$ equals the number of moles of $H_2O(g)$.
D) The rate of evaporation of $H_2O(\ell)$ equals the rate of condensation of $H_2O(g)$.

43. Given the equation representing a system at equilibrium:

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$$

At equilibrium, the concentration of

A) $SO_2(g)$ must equal the concentration of $SO_3(g)$
B) $SO_2(g)$ must be constant
C) $O_2(g)$ must equal the concentration of $SO_2(g)$
D) $O_2(g)$ must be decreasing

44. Given the equation representing a reaction at equilibrium:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + \text{heat}$$

Which change causes the equilibrium to shift to the right?

A) adding a catalyst
B) adding more $O_2(g)$
C) decreasing the pressure
D) increasing the temperature

45. Given the equation representing a system at equilibrium:

$$KNO_3(s) + energy \overset{H_2O}{\longleftrightarrow} K^+(aq) + NO_3^-(aq)$$

Which change causes the equilibrium to shift?

A) increasing pressure
B) increasing temperature
C) adding a noble gas
D) adding a catalyst

46. In which type of reaction can two compounds exchange ions to form two different compounds?

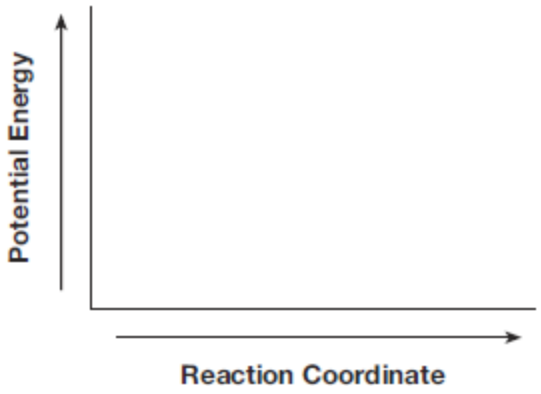
A) synthesis
B) decomposition
C) single replacement
D) double replacement

Base your answers to questions **47** and **48** on the information below and on your knowledge of chemistry.

Carbon monoxide, CO(g), is a toxic gas found in automobile exhaust. The concentration of CO(g) can be decreased by using a catalyst in the reaction between CO(g) and O_2(g). This reaction is represented by the balanced equation below.

$$2CO(g) + O_2 \xrightarrow{catalyst} 2CO_2(g) + energy$$

47. On the labeled axes below, draw the potential energy curve for the reaction represented by this equation.



48. Explain, in terms of collision theory, why an increase in temperature increases the rate of the reaction.

Base your answers to questions **49** and **50** on the information below and on your knowledge of chemistry.

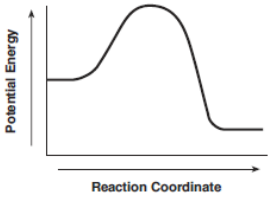
Common household bleach is an aqueous solution containing hypochlorite ions. A closed container of bleach is an equilibrium system represented by the equation below.

$$Cl_2(g) + 2OH^-(aq) \rightleftharpoons ClO^-(aq) + Cl^-(aq) + H_2O(\ell)$$

49. State the effect on the concentration of the ClO^- ion when there is a *decrease* in the concentration of the OH^- ion.

50. Explain why the container must be closed to maintain equilibrium.

Answer Key
Review Heat and Equilibrium

1. **D**
2. **D**
3. **C**
4. **A**
5. **C**
6. **D**
7. **C**
8. **C**
9. **D**
10. **B**
11. **D**
12. **B**
13. **B**
14. **C**
15. **A**
16. **C**
17. **D**
18. **C**
19. **B**
20. **C**
21. **C**
22. **D**
23. gas (g)
24. —When water freezes it expands, making $H_2O(s)$ less dense than $H_2O(l)$. — The distance between the H_2O molecules is greater in the solid phase. — The density of liquid water is greater. — The density of ice is less.
25. –The heat of vaporization of water is 2260 J/g and the heat of fusion for water is only 334 J/g. –The heat of fusion of water is much less than its heat of vaporization.
26. 8 kJ ± 1 kJ
27. –The potential energy remains the same, but the average kinetic energy of the H_2O molecules increases. –There is no change in potential energy. There is an increase in the average kinetic energy.
28. **A**
29. **C**
30. **C**
31. **D**
32. **C**
33. **B**
34. **C**
35. **D**
36. **C**
37. **B**
38. **B**
39. **B**
40. **D**
41. **B**
42. **D**
43. **B**
44. **B**
45. **B**
46. **D**
47. 

48. – The rate of the chemical reaction increases because the reactant molecules move faster and collide with more kinetic energy. – Increasing the temperature causes more frequent collisions. – As molecules acquire more kinetic energy, the probability of effective collisions increases. – More reactant molecules collide with sufficient energy.
49. – The concentration of the ClO^- ion decreases. –$[ClO^-]$ decreases. – lower ClO^- concentration – less ClO^-
50. – The container must be closed so that no matter can enter or leave, thus distributing the equilbrium. – If the container is open, Cl_2 gas escapes. – to keep the concentration of the reactants and products constant