Chemistry · Chemical Equilibrium

Rate of Chemical Reaction

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Multiple choice questions — 33 questions

1 When an amount of water is heated in a closed vessel until the saturated vapour pressure is reached:

All of the following are correct, except .....

(A) Physical equilibrium takes place.

(B) Continued heating at the same temperature increases evaporation.

(C) The number of water molecules that evaporate = the number of vapour molecules that condense.

(D) The vapour pressure becomes equal to the saturated water vapour pressure.

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2 Which of the following equations represents a physical equilibrium process?

(A) $H_2(g) + Cl_2(g) = 2HCl(g)$

(B) $2SO_2(g) + O_2(g) = 2SO_3(g)$

(C) $3O_2(g) = 2O_3(g)$

(D) $N_2(l) = N_2(g)$

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3 Which of the following reactions proceeds in both the forward and the reverse directions?

(A) $Fe(s) + 2HCl(aq) = FeCl_2(aq) + H_2(g)$

(B) $BaCl_2(aq) + K_2SO_4(aq) = 2KCl(aq) + BaSO_4(s)$

(C) $CO(g) + H_2O(v) = CO_2(g) + H_2(g)$ (in a closed vessel)

(D) $2Cu(NO_3)_2(s) = 2CuO(s) + 4NO_2(g) + O_2(g)$

---

4 Which of the following reactions reaches a state of equilibrium some time after the reaction starts?

(A) $KCl(aq) + AgNO_3(aq) = KNO_3(aq) + AgCl(s)$

(B) $CH_3COOC_2H_5(l) + H_2O(l) = C_2H_5OH(aq) + CH_3COOH(aq)$

(C) $K_2SO_4(aq) + (CH_3COO)_2Pb(aq) = 2CH_3COOK(aq) + PbSO_4(s)$

(D) $Zn(s) + 2HCl(aq) = ZnCl_2(aq) + H_2(g)$

---

5 Between which pairs of substances does a complete reaction take place?

(A) $(CH_3COOH + C_2H_5OH)$, $(2Ag^+ + SO_3^{2-})$.

(B) $(2H^+ + Mg)$, $(2Ag^+ + SO_3^{2-})$.

(C) $(CH_3COOC_2H_5 + H_2O)$, $(Na_2S_2O_3 + HCl)$.

(D) $(CH_3COOC_2H_5 + H_2O)$, $(2H^+ + Mg)$.

---

6 The reaction of lead(II) nitrate solution with potassium chloride solution is .....

(A) complete and slow.

(B) incomplete and instantaneous.

(C) complete and instantaneous.

(D) incomplete and slow.

---

7 From the opposite reaction: $X_2(g) + Y_2(g) = 2XY(g)$ (closed vessel)

All of the following describe the state of chemical equilibrium, except .....

(A) The reactants are not completely consumed.

(B) The rate of consumption of (X_2) is half the rate of formation of (XY).

(C) The rate of consumption of (Y_2) equals the rate of consumption of (X_2).

(D) The concentrations of (X_2 , Y_2 , XY) are always equal.

---

8 Which of the following describes the reaction of $HNO_3(aq)$ with sodium thiosulphate?

(A) Complete, with the formation of a gas only.

(B) Complete, with the formation of a gas and a precipitate.

(C) Incomplete and slow.

(D) Incomplete and fast.

---

9 In the reaction represented by the equation: $CaCO_3(s) + 2HCl(aq) \rightarrow H_2O(l) + CO_2(g) + CaCl_2(aq)$

What change happens to the concentration of the ions with time?

(A) $[H^+]$: decreases , $[Ca^{2+}]$: increases , $[Cl^-]$: increases.

(B) $[H^+]$: decreases , $[Ca^{2+}]$: increases , $[Cl^-]$: does not change.

(C) $[H^+]$: decreases , $[Ca^{2+}]$: does not change , $[Cl^-]$: increases.

(D) $[H^+]$: does not change , $[Ca^{2+}]$: increases , $[Cl^-]$: does not change.

---

10 The reaction of heating magnesium bicarbonate solution is .....

(A) complete, with the formation of a precipitate only.

(B) complete, with the formation of a gas and a precipitate.

(C) incomplete, because no precipitate or gas forms.

(D) incomplete, and no chemical equilibrium takes place in it.

---

11 The rate of a chemical reaction depends on all of the following, except .....

(A) the presence of a catalyst.

(B) the concentration of the reactants.

(C) the temperature of the reaction medium.

(D) the heat content of the reactants.

---

12 A reaction was carried out in an open flask between hydrochloric acid and a strip of magnesium.

Which of the following can be used to measure the rate of this reaction before and after it takes place?

(A) The volume of the acid.

(B) The colour of the gas produced.

(C) The concentration of chloride ions.

(D) The mass of the flask and its contents.

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13 All of the following describe a system in a state of equilibrium, except that .....

(A) the reaction is reversible.

(B) the amounts of the substances taking part in the reaction remain equal.

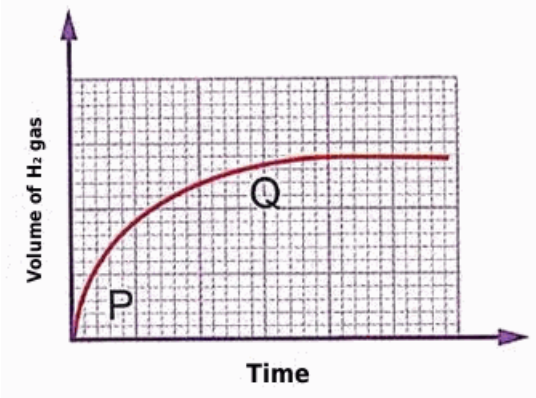
(C) the concentrations of the reactants and the products remain constant.

(D) the rate of the forward reaction equals the rate of the reverse reaction.

---

14 The opposite graph shows the change in the volume of hydrogen gas produced from the reaction of iron filings with excess dilute sulphuric acid.

Which of the following explains the part PQ of the curve?



(A) Iron is a metal of moderate chemical activity.

(B) The decrease in the concentration of the acid with time reduces the speed of the reaction.

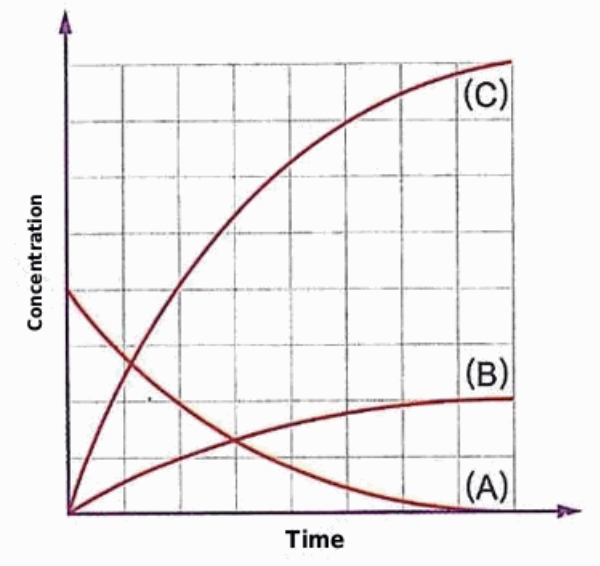
(C) The hydrogen gas produced reduces the speed of the reaction.

(D) The water produced from the reaction dilutes the acid further, which increases the speed of the reaction.

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15 The opposite graph:

represents the reaction .....



(A) A → B + 2C (B) 2A → B + 4C (C) B + 2C → A (D) B + 4C → 2A

---

16 All of the following always describe a reaction at equilibrium, except that .....

(A) the concentration of the reactants always equals the concentration of the products.

(B) the rate of consumption of a substance equals the rate of its formation.

(C) all the reacting and produced substances are present in the reaction medium.

(D) the rate of the forward reaction equals the rate of the reverse reaction.

---

17 All of the following always describe a gaseous chemical reaction at equilibrium, except .....

(A) It takes place in a closed vessel.

(B) It takes place at constant temperature and pressure.

(C) The rate of the forward reaction equals the rate of the reverse reaction.

(D) The reverse reaction stops after a while.

---

18 The following reaction is carried out in a closed vessel:

$H_2O(v) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$

For the reaction to reach the state of equilibrium, ...

(A) the concentrations of both CO and CO_2 increase

(B) the concentrations of both CO and CO_2 decrease

(C) the concentration of CO increases and the concentration of CO_2 decreases

(D) the concentration of CO decreases and the concentration of CO_2 increases

---

19 A reversible reaction reaches the state of equilibrium 60 s after the reaction starts.

All of the following express the value of the rate of the forward reaction (r_1) compared with the value of the rate of the reverse reaction (r_2), except .....

(A) (at 2 s) $r_2 < r_1$ (B) (at 30 s) $r_2 > r_1$ (C) (at 55 s) $r_2 < r_1$ (D) (at 65 s) $r_2 = r_1$

---

20 H_2O and CO react in a closed vessel at a high temperature according to the equation:

$H_2O(v) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$

Before reaching the equilibrium point .....

(A) the rates of the forward and reverse reactions are equal.

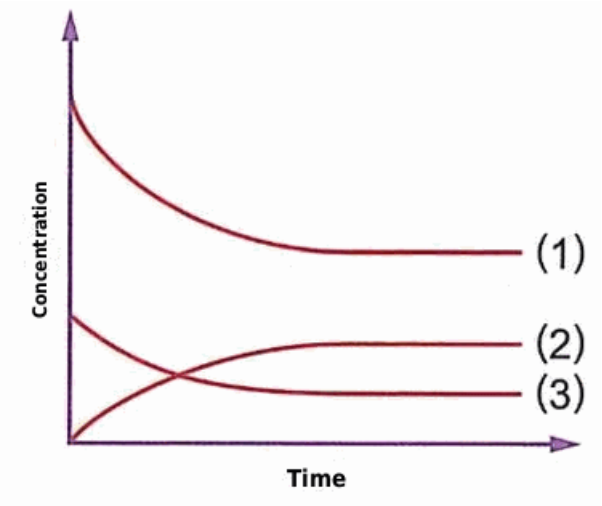
(B) the rates of both the forward and reverse reactions increase.

(C) the rate of the forward reaction decreases and the rate of the reverse reaction increases.

(D) the rate of the forward reaction increases and the rate of the reverse reaction decreases.

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21 The opposite figure represents the rate of preparing ammonia from its elements.
Which of the following is correct?



(A) $[H_2]$: (1) , $[NH_3]$: (2) , $[N_2]$: (3).
(B) $[N_2]$: (1) , $[H_2]$: (2) , $[NH_3]$: (3).
(C) $[H_2]$: (1) , $[N_2]$: (2) , $[NH_3]$: (3).
(D) $[N_2]$: (1) , $[NH_3]$: (2) , $[H_2]$: (3).

22 A chemical substance decomposes at 30°C forming 50 mL of oxygen gas, which took a time of 80 s
Which of the following represents the rate of formation of oxygen gas?

(A) 50 mL / 80 s (B) 50 mL / 30°C (C) 20 mL / 80 s (D) 25 mL / 30°C

23 In the opposite reaction: $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$
At a certain temperature the rate of decomposition of N_2O_5 was 2.5×10^{-6} mol/s
What is the rate of formation of NO_2?

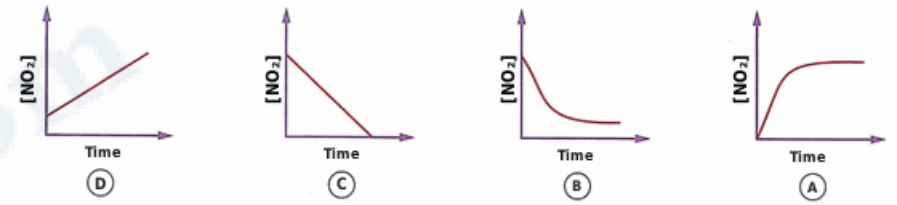
(A) 1×10^{-6} mol/s
(B) 1.25×10^{-6} mol/s
(C) 2.5×10^{-6} mol/s
(D) 5×10^{-6} mol/s

24 When aluminium reacts with copper(II) chloride solution, 0.56 g of copper was observed to be produced in 1 min
[Cu = 63.5 , Al = 27]
What is the mass of aluminium consumed in 20 s?

(A) 0.053 g (B) 0.12 g (C) 0.16 g (D) 0.37 g

25 In the equilibrium reaction: $2NO_2(g) \rightleftharpoons N_2O_4(g)$

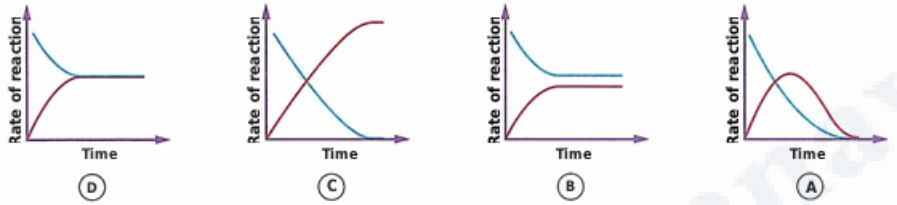
Which graph represents $[NO_2]$ during the reaction until the state of equilibrium is reached?



26 The following equation represents the equilibrium reaction between (X) and (Y) to produce the compound (Z):

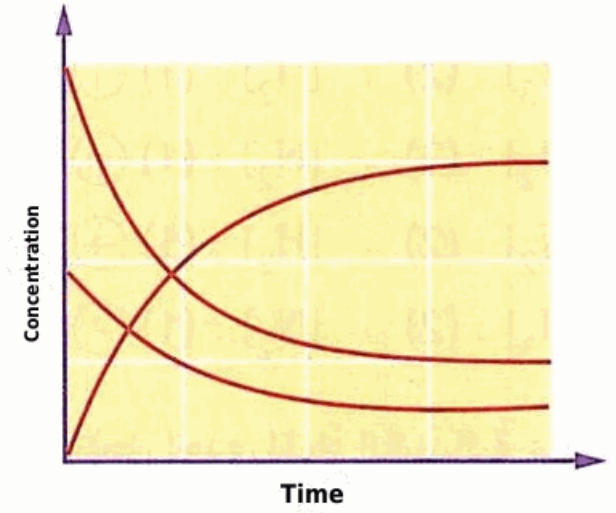
$X + Y \rightleftharpoons Z$

Which of the following represents the change in the rate of each of the forward reaction and the reverse reaction with time?



27 The opposite graph represents the concentrations of three gases in a reversible reaction that reaches the state of equilibrium.

Which reaction does this graph represent?



(A) $2NO_2(g) \rightleftharpoons N_2(g) + 2O_2(g)$

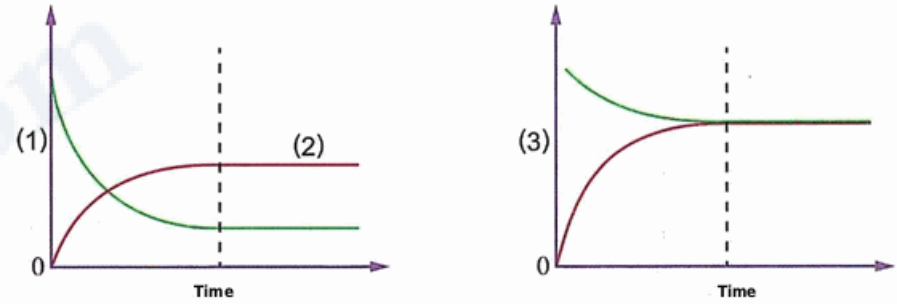
(B) $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(v)$

(C) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(D) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

28 The following two graphs represent the reaction: $2NO_2(g) \rightleftharpoons N_2O_4(g)$

Which of the following is correct?



(A) (1) : concentration , (2) : NO_2 , (3) : rate of reaction.

(B) (1) : concentration , (2) : N_2O_4 , (3) : rate of reaction.

(C) (1) : rate of reaction , (2) : N_2O_4 , (3) : concentration.

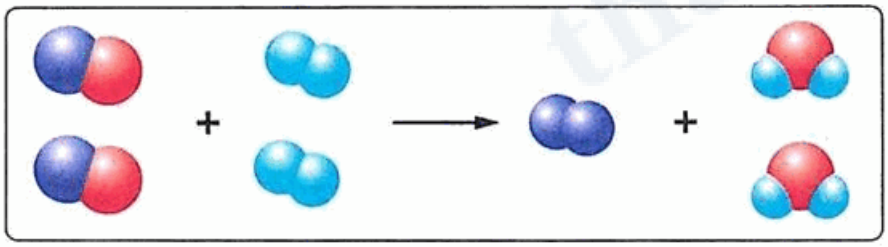
(D) (1) : rate of reaction , (2) : NO_2 , (3) : concentration.

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29 From the opposite figure:

What is the type of bonding in the reactants,

and how is the rate of this reaction classified?



(A) Covalent / slow. (B) Covalent / fast. (C) Ionic / slow. (D) Ionic / fast.

---

30 Which of the following equations represents the reaction with the fastest rate?

(A) $C(s) + O_2(g) \rightarrow CO_2(g)$

(B) $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

(C) $2Al(s) + 3CuCl_2(aq) \rightarrow 2AlCl_3(aq) + 3Cu(s)$

(D) $FeCl_3(aq) + 3NaOH(aq) \rightarrow 3NaCl(aq) + Fe(OH)_3(s)$

---

31 The reaction of a known mass of zinc carbonate pieces with excess dilute hydrochloric acid took 5 minutes.

When the previous reaction is repeated after crushing the same mass of zinc carbonate pieces, the reaction is completed in .....

(A) less time / because the zinc carbonate particles are larger.

(B) less time / because the surface area of zinc carbonate exposed to the reaction is larger.

(C) the same time / because the mass of zinc carbonate did not change.

(D) more time / because the number of zinc carbonate particles is larger while the concentration of the acid is constant.

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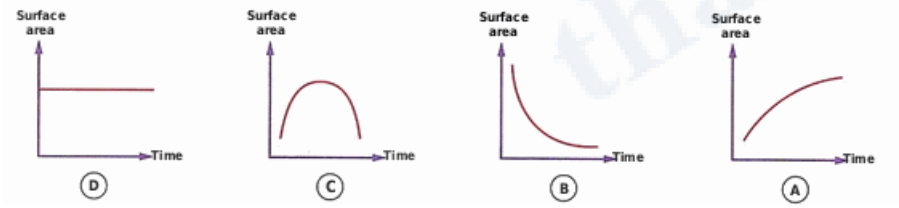
32 A piece of iron needed a time of 270 s to react with 0.1 M HCl acid.

What is the rate of reaction of the same acid with the same mass of iron filings?

(A) 3.7×10^{-4} M/s (B) 2.5×10^{-4} M/s (C) 5.4×10^{-3} M/s (D) 6.1×10^{-5} M/s

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33 Which of the following graphs represents the relation between the surface area of the reactants and the reaction time?



Essay questions — 4 questions

1 When does equilibrium take place in a closed flask between:

(1) ice and liquid water (at 0°C)?

(2) liquid bromine and bromine vapour (at 20°C)?

2 Ammonia gas is prepared from its elements:

(1) Why does the percentage of ammonia gas produced not represent 100% of the reacting substances?

(2) What is the effect of bringing a dry red litmus paper near the gas produced? Explain.

3 Two experiments were carried out on the reaction of calcium carbonate with dilute hydrochloric acid under the same conditions of pressure and temperature:

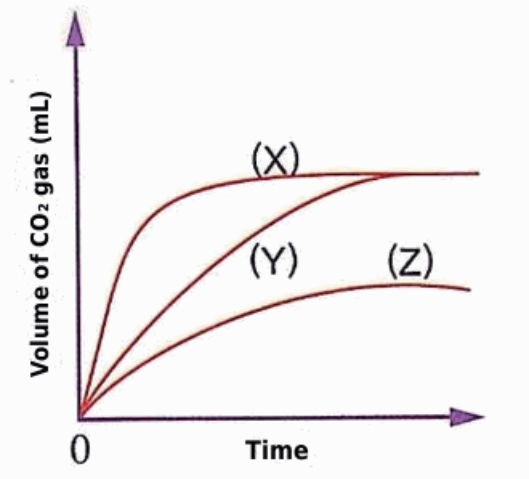
• In experiment (1): 20 mL of dilute hydrochloric acid were added to excess calcium carbonate powder.

• In experiment (2): 20 mL of dilute hydrochloric acid were added to excess calcium carbonate pieces.

From the opposite graph, identify, with explanation, the symbol of the curve that represents:

(1) experiment (1).

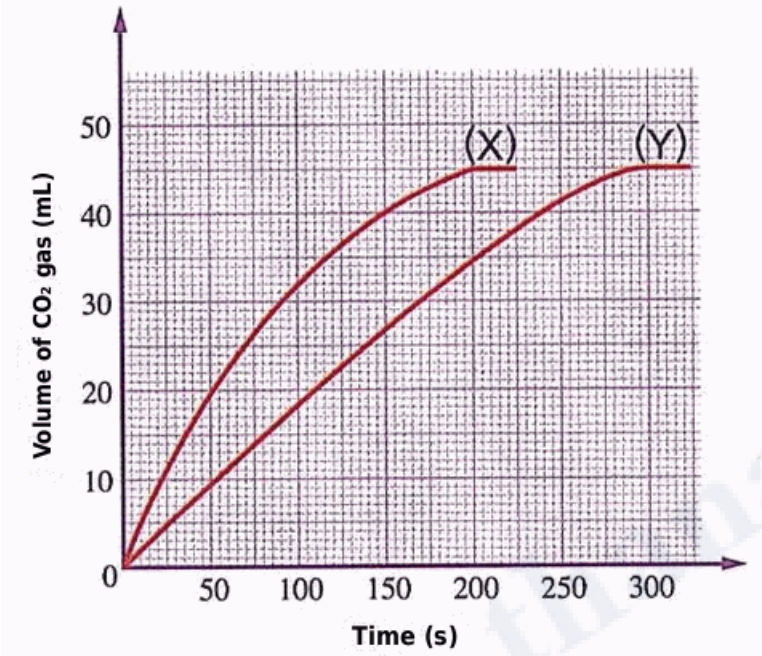
(2) experiment (2).



4 The opposite graph represents the volume of carbon dioxide gas produced from the reaction of pieces of calcium carbonate of equal masses with hydrochloric acid. Medium pieces of calcium carbonate were used in the first experiment and small pieces in the second experiment:

(1) Which of the two curves (X) and (Y) represents the reaction of the small pieces with the acid? Explain.

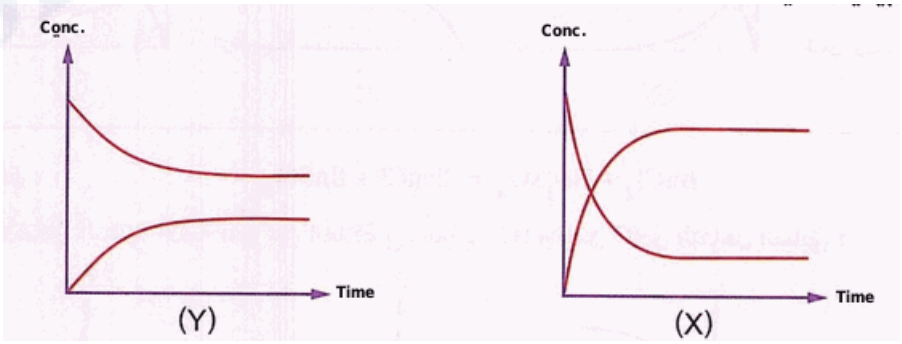
(2) What is the time taken to consume all the medium-sized pieces of calcium carbonate?



Past exam questions — 11 questions

1 From the following graphs:

Which of the following statements is correct?



(A) Graph (X) : Kc = 1 and the reverse direction is dominant.

(B) Graph (Y) : Kc = 1 and the forward direction is dominant.

(C) Graph (X) : Kc > 1 and the forward direction is dominant.

(D) Graph (Y) : Kc > 1 and the reverse direction is dominant.

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2 Which of the following equations represents a process in which the rate of the forward reaction equals the rate of the reverse reaction?

(A) $AgNO_3(aq) + NaCl(aq) = AgCl(s) + NaNO_3(aq)$

(B) $HCl(aq) + H_2O(l) = H_3O^+(aq) + Cl^-(aq)$

(C) $N_2(g) + 3H_2(g) = 2NH_3(g)$ (open vessel)

(D) $CH_3COOH(aq) + H_2O(l) = H_3O^+(aq) + CH_3COO^-(aq)$

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3 Which of the following reactions represents a state of equilibrium in an open vessel?

(A) $CaCO_3(s) = CaO(s) + CO_2(g)$

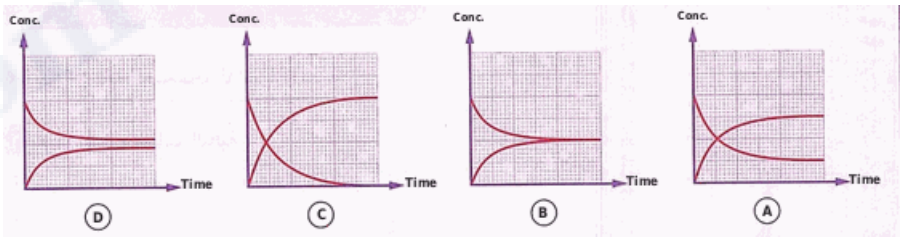
(B) $2Cu(NO_3)_2(s) = 2CuO(s) + 4NO_2(g) + O_2(g)$

(C) $FeCl_3(aq) + 3NH_4SCN(aq) = Fe(SCN)_3(aq) + 3NH_4Cl(aq)$

(D) $Zn(s) + CuSO_4(aq) = ZnSO_4(aq) + Cu(s)$

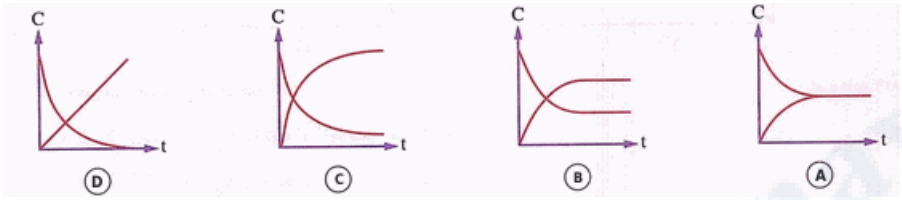
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4 Which of the following graphs represents the relation between the concentrations of the products and the reactants when a piece of magnesium metal is placed in dilute sulphuric acid solution?



5 In the reaction: $BaCl_2 + Na_2SO_4 = 2NaCl + BaSO_4$

Which of the following graphs represents the relation between concentration (C) and time (t) in the previous reaction?



6 (A) : $AgNO_3(aq) + NaBr(aq) = AgBr(s) + NaNO_3(aq)$

(B) : $2NO(g) + O_2(g) = 2NO_2(g)$ (closed vessel)

(C) : $CH_3COOH(l) + C_2H_5OH(l) = CH_3COOC_2H_5(aq) + H_2O(l)$

(D) : $N_2(g) + 3H_2(g) = 2NH_3(g)$ (closed vessel)

Which of the previous reactions is a complete reaction?

7 All of the following are reversible reactions, except .....

(A) $CO_2(g) + H_2(g) = CO(g) + H_2O(v)$ (closed vessel)

(B) $CH_3COOH(l) + C_2H_5OH(l) = CH_3COOC_2H_5(aq) + H_2O(l)$

(C) $2Na(s) + 2HCl(aq) = 2NaCl(aq) + H_2(g)$

(D) $2NO_2(g) = N_2O_4(g)$ (closed vessel)

8 Which of the following statements describes a chemical reaction in a state of equilibrium?

(A) The speed of the forward reaction is always greater than the speed of the reverse reaction.

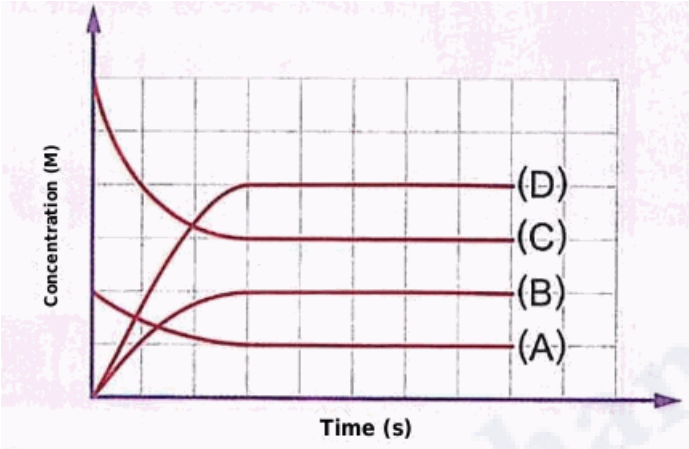
(B) The reaction is always static, not dynamic.

(C) The concentrations of the products and the reactants are always constant.

(D) The concentrations of the products and the reactants are always equal.

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9 Which of the following represents the opposite chart?



(A) $2A + B \rightleftharpoons 2C + 4D$

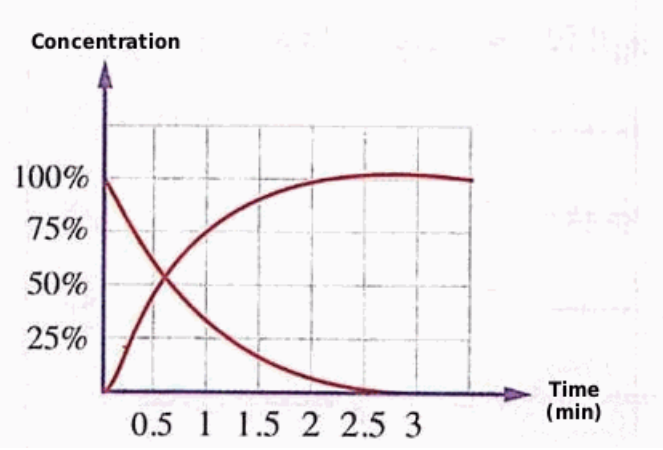
(B) $A + 3C \rightleftharpoons 2B + 4D$

(C) $2A + B \rightarrow 2C + 4D$

(D) $A + 3C \rightarrow 2B + 4D$

---

10 Which of the following statements represents the two curves shown in the opposite graph?



(A) Sodium chloride solution + silver nitrate solution.

(B) Iron nails covered with oil.

(C) Iron nails covered with water.

(D) Magnesium pieces + dilute hydrochloric acid.

11 Which of the following reactions is the fastest?

(A) $Mg(s) + 2HCl(aq) = MgCl_2(aq) + H_2(g)$ (a piece)

(B) $FeSO_4(aq) + 2NaOH(aq) = Fe(OH)_2(s) + Na_2SO_4(aq)$

(C) $CH_3COOH(l) + CH_3OH(l) = CH_3COOCH_3(aq) + H_2O(l)$

(D) $Fe(s) + \frac{3}{2}\ O_2(g) + 3H_2O(l) = 2Fe(OH)_3(s)$ (rusting of iron)

Answer key and solutions

Multiple choice questions

1 B	2 D	3 C	4 B	5 B	6 C	7 D	8 B	9 B	10 B
11 D	12 D	13 B	14 B	15 B	16 A	17 D	18 D	19 B	20 C
21 A	22 A	23 D	24 A	25 B	26 D	27 D	28 B	29 A	30 D
31 B	32 C	33 B							

1 **Answer (B)**

When the saturated vapour pressure is reached in a closed vessel, physical equilibrium takes place.

Rate of evaporation = rate of condensation.

Continued heating at the same temperature does not increase evaporation.

2 **Answer (D)**

Physical equilibrium takes place between two physical states of the same substance.

$N_2(l) \rightleftharpoons N_2(g)$ is a change in physical state only.

The other equations are chemical reactions.

3 **Answer (C)**

A reversible reaction takes place in a closed vessel, and none of its products leaves the reaction medium.

In (A) and (D) a gas is given off, and in (B) a precipitate forms.

(C) is in a closed vessel, so it proceeds in both directions.

4 **Answer (B)**

Equilibrium takes place in reversible reactions only.

The esterification reaction (B) is reversible: an ester and water form and react together again.

In (A) and (C) a precipitate forms and in (D) a gas is given off, so all of them are complete reactions.

5 **Answer (B)**

In a complete reaction a precipitate or a gas forms.

$2Ag^+ + SO_3^{2-} \rightarrow Ag_2SO_3$ (precipitate).

$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ (a gas is given off).

The reaction of an acid with an alcohol and of an ester with water is reversible.

6 **Answer (C)**

$Pb(NO_3)_2 + 2KCl \rightarrow PbCl_2 + 2KNO_3$

A precipitate of $PbCl_2$ forms, so the reaction is complete.

Reactions of ions in solutions are instantaneous.

7 **Answer (D)**

At equilibrium the concentrations stay constant and are not necessarily equal.

8 **Answer (B)**

HNO_3 with sodium thiosulphate forms a precipitate of sulphur S and SO_2 gas.

The reaction is complete, with the formation of a gas and a precipitate.

9 **Answer (B)**

H^+ is consumed in the reaction, so its concentration decreases.

$CaCl_2$ forms, so the concentration of Ca^{2+} increases.

Cl^- does not take part in the reaction, so its concentration does not change.

10 **Answer (B)**

$Mg(HCO_3)_2 \rightarrow MgCO_3 + H_2O + CO_2$

A precipitate of $MgCO_3$ and CO_2 gas form, so the reaction is complete.

11 **Answer (D)**

The rate of reaction depends on concentration, temperature and the catalyst.

The heat content of the reactants does not affect the rate of reaction.

12 **Answer (D)**

In an open flask H_2 gas is given off, so the mass of the flask and its contents decreases.

Measuring the decrease in mass with time gives the rate of reaction.

13 **Answer (B)**

At equilibrium the amounts of the substances remain constant, not equal.

14 **Answer (B)**

In the part PQ the slope of the curve decreases, i.e. the rate of reaction decreases.

The reason is that the concentration of the acid decreases with time.

15 **Answer (B)**

The concentration of (A) decreases, so it is a reactant; the concentrations of (B) and (C) increase, so they are products.

The ratio between the changes in concentration of A : B : C ≈ 2 : 1 : 4

The suitable equation: $2A \rightarrow B + 4C$

16 **Answer (A)**

The concentration of the reactants is not necessarily equal to the concentration of the products.

What matters is that they remain constant at equilibrium.

17 **Answer (D)**

At equilibrium the reverse reaction keeps going on.

Its rate equals the rate of the forward reaction.

18 **Answer (D)**

The reaction starts with the reactants H_2O and CO.

Their concentration decreases and the concentration of the products CO_2 and H_2 increases until equilibrium.

19 **Answer (B)**

Before equilibrium (less than 60 s) the rate of the forward reaction is greater than that of the reverse reaction.

At 30 s : $r_2 < r_1$ and not $r_2 > r_1$

After 60 s the two rates are equal.

20 **Answer (C)**

Before equilibrium the concentration of the reactants decreases, so the rate of the forward reaction decreases.

The concentration of the products increases, so the rate of the reverse reaction increases.

21 **Answer (A)**

The two decreasing curves are reactants, and the increasing one is a product.

H_2 has the larger coefficient, so it decreases more and it is (1); N_2 is (3).

NH_3 is a product whose concentration increases, and it is (2).

22 **Answer (A)**

Rate of formation of the gas = volume ÷ time

= 50 mL / 80 s

23 **Answer (D)**

$N_2O_5 : NO_2 = 2 : 4 = 1 : 2$

Rate of formation of $NO_2 = 2 \times 2.5 \times 10^{-6} = 5 \times 10^{-6}$ mol/s

24 **Answer (A)**

Mass of Cu produced in 20 s = $0.56 \times 20 \div 60 = 0.187$ g

$2Al \rightarrow 3Cu$

(2×27) g $\rightarrow (3 \times 63.5)$ g

Mass of Al consumed = $2 \times 27 \times 0.187 \div (3 \times 63.5) = 0.053$ g

25 **Answer (B)**

NO_2 is a reactant, so its concentration decreases gradually.

The slope of the curve decreases with time, then the curve levels off at equilibrium without reaching zero.

26 **Answer (D)**

The rate of the forward reaction decreases as the concentration of the reactants decreases.

The rate of the reverse reaction increases as the concentration of the product increases.

At equilibrium the two rates become equal and constant.

27 **Answer (D)**

There are two decreasing curves (reactants) and one increasing curve (product).

The decrease of one reactant is twice the decrease of the other, and the increase of the product equals the decrease of the first reactant.

This matches: $2SO_2 + O_2 \rightleftharpoons 2SO_3$

28 **Answer (B)**

The first graph represents concentration: one curve decreases, so it is NO_2, and (2) increases, so it is N_2O_4.

The second graph represents the rate of reaction: the forward and reverse rates become equal at equilibrium (3).

29 **Answer (A)**

The reactants NO and H_2 are covalent molecules.

A reaction between covalent molecules is slow because it requires breaking bonds.

30 **Answer (D)**

Ionic reactions in solutions are instantaneous.

In (D) a precipitate of $Fe(OH)_3$ forms from the combination of ions, so it is the fastest.

31 **Answer (B)**

Crushing zinc carbonate increases its surface area exposed to the reaction.

So the rate of reaction increases and the time needed decreases.

32 **Answer (C)**

Iron filings have a larger surface area than the piece, so the rate of reaction is greater.

Rate of reaction of the piece = $0.1 \div 270 = 3.7 \times 10^{-4}$ M/s

The value greater than it is 5.4×10^{-3} M/s

33 **Answer (B)**

The surface area of the reacting solid decreases with time.

So the curve is (B).

Essay questions

1 **Model answer**

(1) When the rate of freezing equals the rate of melting.

(2) When the rate of evaporation equals the rate of condensation.

2 **Model answer**

(1) Because the reaction is a reversible reaction, in which part of the ammonia gas produced changes back into its elements.

(2) Its colour does not change, because there is no water for the ammonia gas to dissolve in.

3 **Model answer**

(1) Experiment (1) is represented by curve (X), because using calcium carbonate as a powder increases its surface area exposed to the reaction, so its rate of reaction is the greatest.

(2) Experiment (2) is represented by curve (Y), because it produces the same volume of CO_2 gas (the volume and concentration of the acid are equal in both experiments) but the rate of reaction is slower, because the calcium carbonate is in the form of pieces.

4 **Model answer**

(1) Curve (X), because it represents obtaining the same amount of gas (45 mL) in less time (200 s), as a result of the increase in the surface area exposed to the reaction.

(2) 300 s

Past exam questions

1	2	3	4	5	6	7	8	9	10
C	D	C	C	D	A	C	C	B	D

11
B

1 **Answer (C)**

(X) : the concentration of the products at equilibrium is greater than the concentration of the reactants.

Kc > 1 and the forward direction is dominant.

2 **Answer (D)**

At equilibrium the rates of the forward and reverse reactions are equal, and this happens in reversible reactions.

The ionization of weak acetic acid is reversible, while HCl ionizes completely.

3 **Answer (C)**

Equilibrium in an open vessel takes place for a reaction from which no gaseous product escapes.

The ions in solution (C) react in both directions.

In (A) and (B) a gas is given off, and (D) is a complete displacement reaction.

4 **Answer (C)**

The reaction between Mg and the acid is a complete reaction.

The concentration of the acid decreases until it reaches zero and the concentration of the product increases.

5 **Answer (D)**

$BaCl_2 + Na_2SO_4 \rightarrow 2NaCl + BaSO_4$

A precipitate of $BaSO_4$ forms, so the reaction is complete.

The concentration of the reactant decreases until it reaches zero and the concentration of the product increases.

6 **Answer (A)**

In a complete reaction a precipitate or a gas forms.

In (A) a precipitate of AgBr forms.

(B) and (D) are reversible in a closed vessel, and (C) is a reversible esterification reaction.

7 **Answer (C)**

In (C) H_2 gas is given off, so it is a complete reaction.

The other reactions are reversible.

8 **Answer (C)**

At equilibrium the concentrations of the reactants and the products are constant, not equal.

Rate of the forward reaction = rate of the reverse reaction.

9 **Answer (B)**

The concentrations of the reactants A and C decrease, and the concentrations of the products B and D increase.

The concentrations level off without any reactant disappearing, so the reaction is reversible.

The suitable equation: $A + 3C \rightleftharpoons 2B + 4D$

10 **Answer (D)**

The concentration of the reactant reaches zero, so the reaction is complete.

The time is in minutes, so the reaction is relatively slow, like the reaction of Mg with the acid.

The reaction of ions is instantaneous, and rusting of iron is very slow.

11 **Answer (B)**

Reactions of ions in solutions are instantaneous.

$FeSO_4 + 2NaOH \rightarrow Fe(OH)_2 + Na_2SO_4$ forms a precipitate, so it is the fastest.