Enter All Answers in the Scantron Sheets

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) An aqueous solution is prepared by dissolving 1.05 grams of hemoglobin in 100.0 ml of solution. The solution has an osmotic pressure of 2.85 mmHg at 25°C. What is the molar mass of hemoglobin?
   A) 5740 g/mol
   B) 68,500 g/mol
   C) 90.0 g/mol
   D) 622 g/mol

2) An unknown element crystallizes in a face-centered cubic unit cell with an edge length of 392.4 pm. The solid has a density of 21.09 g/cm^3. What is the atomic weight of the solid?
   A) 6.90 amu
   B) 241.7 amu
   C) 74.4 amu
   D) 191.8 amu

3) The K_W of water at 50°C is 5.47×10^{-14}. What is the hydroxide concentration in pure water at 50°C?
   A) 2.34×10^{-7} M
   B) 1.00×10^{-7} M
   C) 5.45×10^{-7} M
   D) 4.68×10^{-7} M

4) What types of gases do not obey Henry's law?
   A) Gases that do not follow the ideal gas law
   B) Gases that react chemically with a solvent
   C) Gases that have very low solubilities
   D) Gases that are difficult to liquefy

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5) Which of these acid-conjugate base pairs would make a buffer with a pH of 7.50?
   A) Acetic acid/sodium acetate ($pK_a = 4.75$)
   B) Ammonium chloride/ammonia ($pK_a = 9.25$)
   C) Carbonic acid/sodium bicarbonate ($pK_a = 6.38$)
   (D) Hypochlorous acid/sodium hypochlorite ($pK_a = 7.42$)

6) Carbon tetrachloride has a normal boiling point of 76.8°C and an enthalpy of vaporization of 29.8 kJ/mol. What is the vapor pressure of carbon tetrachloride at 25°C?
   A) 910 mmHg
   (B) 128 mmHg
   C) 690 mmHg
   D) 634 mmHg

Use the diagram in Figure 1 for the question that follows.

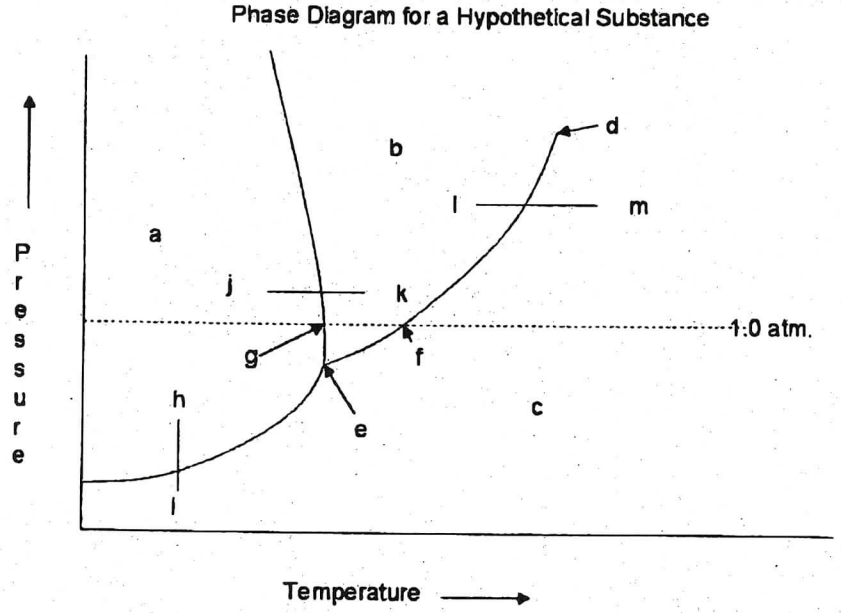

Figure 1. A phase diagram for a hypothetical substance

7) What is represented by the point d on the diagram in Figure 1?
   (A) Critical point
   B) Triple point
   C) Normal boiling point
   D) Melting point

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0.3078 0.7618

8) A gas sample has the following partial pressures: P(oxygen) = 234 mmHg, P(nitrogen) = 579 mmHg, and P(water) = 36.3 mmHg. What is the mole fraction of water in the gas mixture?

(A) 0.043 0.04776
B) 0.063
C) 0.045
D) 0.059

✓

9) An unknown gas has a density of 2.35 g/L at a pressure of 750.1 mmHg and 25°C. What is the molecular weight of the gas?

A) 76.7 g/mol
B) 5.80 g/mol
(C) 58.3 g/mol
D) 4.89 g/mol

✓

10) A solution of lead from a battery plant has a concentration of 3.65×10^{-7} M. What is this concentration in ppb? Assume the solution has a density of 1.000 g/ml.

A) 75.6 ppb
B) 1361 ppb
(C) 365 ppb
D) 6.57 ppb

✓

11) How does the kinetic molecular theory of gases explain the relationship between pressure and temperature?

(A) At higher temperatures, the molecules have more energy and run into each other more often, increasing the pressure. ✓
(B) At a higher temperature, the molecules collide with the walls more often and with more force, increasing the pressure.
(C) At higher temperatures, there are more collisions with the walls, but each collision transfers less energy.
(D) At higher temperatures, the molecules have more energy. When they run into the walls, they transfer less of the energy to the walls.

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$\frac{V_1}{V_2} = \frac{n_1}{n_2}$

12) The statement "At constant temperature and pressure, the volume of a sample of gas is proportional to the number of moles of gas" is

A) Avogadro's law.
B) Gay-Lussac's law.
C) Boyle's law.
D) Charles's law.

$\frac{P}{V}$

0.1435 13.66

13) What is the freezing point of a solution of 14.6 grams of calcium chloride in 246 grams of water? The freezing point depression constant for water is 1.86°C/m.

A) 2.98 °C
B) -2.98 °C
C) 0.995 °C
D) -0.995 °C

14) What is the strongest intermolecular force present in liquid bromine (Br_2)?

A) London dispersion forces
B) Hydrogen bonds
C) Dipole-dipole attractions
D) Covalent bonds

$\frac{(NO^2)(Br_2)}{(NOBr)^2}$

15) The equilibrium constant for the reaction

$$2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g) \qquad K = 6.2 \times 10^{-3}$$

is 6.2×10^{-3} at 300°C. A mixture of gases has the following composition: [NOBr] = 8.0×10^{-4} mol/L, [NO] = 4.5×10^{-2} mol/L, and [Br_2] = 1.6×10^{-2}. What is the value of Q?

A) 51
B) 1100
C) 6.2×10^{-3}
D) 0.90

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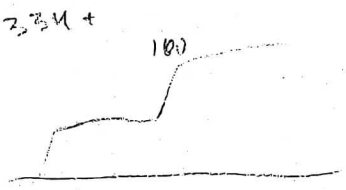
16) One possible way to convert seawater into drinking water is through distillation. How much energy is required to take 325 ml of water at 20°C and convert it to steam at 100°C? Remember: specific heat of water = 4.184J/g°C, ΔH_{vap} = 40.7 kJ/mol, and density of water at 20°C = 0.998 g/ml.

A) 441 kJ
B) 842 kJ
C) 122 kJ
D) 469 kJ



17) Consider the titration of 25.00 ml of 0.200 M benzoic acid ($K_a = 6.3 \times 10^{-5}$) with 0.100 M sodium hydroxide. What is the pH of the solution when 35.00 ml of sodium hydroxide has been added?

A) 3.83
B) 4.57
C) 4.50
D) 3.90

$pH = pK_a + \log\left(\frac{base}{acid}\right)$ $\frac{0.0035}{0.005}$

$= 4.2$ ✓

18) Carbonyl bromide [$COBr_2(g)$] decomposes to $CO(g)$ and $Br_2(g)$ with an equilibrium constant (K_c) of 0.190 at 73°C:

$\frac{(Br)(CO)}{(COBr_2)} = 0.19$ $\frac{x^2}{0.005} = 0.19$

$$COBr_2(g) \rightleftharpoons CO(g) + Br_2(g).$$

A 0.015 mol sample of $COBr_2(g)$ was heated in a 2.5 L flask until equilibrium was attained. What is the concentration of CO at equilibrium?

A) 1.48×10^{-2} M
B) 6.07×10^{-3} M
C) 5.82×10^{-3} M
D) 3.38×10^{-2} M ✓

Enter All Answers in the Scantron Sheets

19) The chemical system

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

is at equilibrium at 300°C. What would the effect on the system be if an additional 1.0 mol of NO(g) was added to the system?

A) The reaction would proceed in reverse to use some of the NO that was added.
B) The reaction would proceed in the forward reaction to increase the concentration of Cl_2.
C) The system would not return to an equilibrium mixture.
D) There would be no additional reaction since only one product was added.

20) Why does water have a very high surface tension?

A) The surface tension of water is high because water molecules do not like to interact with other water molecules.
B) The surface tension of water is high because of the strong intermolecular forces present in liquid water.
C) The surface tension of water is high because it has a high boiling point.
D) The surface tension of water is high because the molecular weight is low but the freezing point is high.

21) How does an amorphous solid differ from a crystalline solid?

A) An amorphous solid has a very small unit cell.
B) The forces holding the layers of the solid together are very weak.
C) The amorphous solid has an extended long-range order.
D) The components are not arranged in a regular array.

22) Trimethylamine has a K_b of 7.4×10^{-5}. What is the pK_a of the conjugate acid of trimethylamine?

A) 4.93
B) 9.87
C) 9.07
D) 4.13

Enter All Answers in the Scantron Sheets

23) For the reaction

$$PH_3BCl_3(s) \rightleftharpoons PH_3(g) + BCl_3(g),$$

$K = (PH_3)(BCl_3)$

what is the correct equilibrium expression?

(A) $K = [PH_3][BCl_3]$

B) $K = \dfrac{[PH_3]\,[BCl_3]}{[PH_3\,BCl_3]}$

C) $K = \dfrac{1}{[PH_3\,BCl_3]}$

D) $K = \dfrac{[PH_3\,BCl_3]}{[PH_3][BCl_3]}$

24) A lustrous solid with high electrical conductivity was prepared in the laboratory. It has a melting point of 186°C, and the liquid conducts electricity. What kind of solid is it?

A) Covalent
(B) Metallic
C) Ionic
D) Molecular

Multiple Choice Questions: **1 mark each.**
Fill in all answers on the TRS form. Answers on the TRS form are considered Final.

1. The temperature of a gas in a sealed container changes from 40.0 to 80.0°C. If the volume remains constant, the pressure will change from 750 mmHg to

   [A] 375 mmHg.

   [B] 665 mmHg.

   [C] 846 mmHg.

   [D] 893 mmHg.

   [E] 1500 mmHg.

2. Carbon monoxide is toxic because it can successfully compete with oxygen for hemoglobin (Hb) sites according to the following equilibrium

   $Hb(O_2)_4 + 4CO \rightleftharpoons Hb(CO)_4 + 4O_2$

   From LeChatalier's Principle, how is CO poisoning reversed?

   [A] by increasing the amount of Hb

   [B] by increasing the CO pressure

   [C] by increasing the O_2 pressure

   [D] by increasing the CO_2 pressure

   [E] by decreasing the amount of Hb

3. A 25.00-mL sample of propionic acid, CH_3CH_2COOH ($K_a = 1.3 \times 10^{-5}$), of unknown concentration was titrated with 0.104 M KOH. The equivalence point was reached when 35.31 mL of base had been added. What is the concentration of the propionate ion at the equivalence point?

   [A] 0.0531 M

   [B] 0.0609 M

   [C] 0.0914 M

   [D] 0.128 M

   [E] 0.147 M

   ⇒ moles KOH added

   $= 35.31 \times 10^{-3}\,L \times \frac{0.104\ mol}{L}$

   $= 0.00367$

   @ eq. pt

   0.00367 = moles of acid reacted

   ⇒

Multiple Choice Questions: **1 mark each.**
Fill in all answers on the TRS form. Answers on the TRS form are considered Final.

4. In which of the following reactions will the pressure increase after the reaction assuming that no change in temperature was observed?

   [A] $2\,NO_{(g)} + O_{2(g)} \rightarrow 2\,NO_{2(g)}$

   [B] $Cl_{2(g)} + 3\,F_{2(g)} \rightarrow 2\,ClF_{3(g)}$

   [C] $4\,NH_{3(g)} + 5\,O_{2(g)} \rightarrow 4\,NO_{(g)} + 6\,H_2O_{(g)}$

   [D] $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ ← phase chg.

   [E] $C_2H_6O_{(l)} + 3\,O_{2(g)} \rightarrow 2\,CO_{2(g)} + 3\,H_2O_{(l)}$

5. If 20 mL of 0.10 M NaOH are added to 30 mL of 0.20 M HOAc, what is the pH of the resulting solution? ($K_a = 1.8 \times 10^{-5}$ for HOAc.)

   $n\,NaOH = 0.002\ mol$
   $n\,HOAc = 0.006\ mol$

   [A] 4.4

   [B] 4.7

   [C] 8.7

   [D] 5.0

   [E] 2.7

6. For the equilibrium
   $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
   $K_c = 4.0$ at 228°C. Pure PCl_5 is added to the reaction system. At equilibrium there is 0.16 M PCl_5. What is the concentration of PCl_3 in this system?

   [A] 0.16 M

   [B] 0.20 M

   [C] 0.40 M

   [D] 0.80 M

   [E] 1.6 M

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

I

C

E 0.16

$\Rightarrow \frac{x^2}{0.16} = 4.0$

4.744

Multiple Choice Questions: **1 mark each.**
Fill in all answers on the TRS form. Answers on the TRS form are considered Final.

7. The hydronium-ion concentration of a 0.050 M lactic acid solution is 2.62×10^{-3}. The acid dissociation constant is 1.37×10^{-4}. The pH of this lactic acid solution is

   [A] 0.42.

   [B] 1.30.

   [C] 2.58.

   [D] 3.86.

   [E] 5.94.

8. At standard conditions, 2.75 L of a gas weighed 5.39 g. The gas is

   [A] NF_3. — 70.98 g/mol V = 2.75 L

   [B] N_2. — 28.02 g/mol

   [C] NO. — 30.01 g/mol 22.4 L/mol @ STP.

   [D] N_2O. — 44.02 g/mol ←

   [E] F_2. — 37.98 g/mol

9. For the equilibrium system
   $CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$ $\Delta H = +42$ kJ/mol
   K equals 1.6 at 1260 K. If 0.15 mol each of CO_2, H_2, CO, and H_2O (all at 1260 K) were placed in a 1.0-L thermally insulated vessel that was also at 1260 K, then when the system came to equilibrium,

   [A] the temperature would increase and the mass of CO would decrease.

   [B] the temperature would decrease and the mass of CO would decrease.

   [C] the temperature would remain constant and the mass of CO would increase.

   [D] the temperature would decrease and the mass of CO would increase.

   [E] the temperature would increase and the mass of CO would increase.

$\frac{L}{mol} \times \frac{mol}{g}$

$\frac{mol}{L} \times \frac{g}{mol}$

Multiple Choice Questions: **1 mark each.**
Fill in all answers on the TRS form. Answers on the TRS form are considered Final.

10. Which of the following reactions represent(s) the amphoteric behavior of aluminum?
    1. $2Al(s) + 6H^+(aq) \longrightarrow 2Al^{3+}(aq) + 3H_2(g)$
    2. $2Al(s) + Fe_2O_3(s) \longrightarrow Al_2O_3(s) + 2Fe(s)$ ← Displacement rxn!
    3. $2Al(s) + 2OH^-(aq) + 6H_2O(l) \longrightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

    [A] 1 only
    [B] 2 only
    [C] 3 only
    [D] 1 and 3 only
    [E] 1, 2, and 3

11. A sample of hydrogen was collected by water displacement at 23.0°C and an atmospheric pressure of 735 mmHg. Its volume is 568 mL. After water vapor is removed, what volume would the hydrogen occupy at the same conditions of pressure and temperature? (The vapor pressure of water at 23.0°C is 21 mmHg.)

    Const
    T = 23°C ; P = 735 mm = 0.967 atm
    V = 0.568 L

    [A] 509 mL
    [B] 539 mL
    [C] 552 mL
    [D] 568 mL
    [E] 585 mL

12. Which of the following can we predict from an equilibrium constant for a reaction?
    1. The extent of a reaction
    2. Whether the reaction is fast or slow
    3. Whether a reaction is exothermic or endothermic ← only by ΔH.

    [A] 1 only
    [B] 2 only
    [C] 3 only
    [D] 1 and 2 only
    [E] 1 and 3 only

Multiple Choice Questions: **1 mark each.**
Fill in all answers on the TRS form. Answers on the TRS form are considered Final.

13. Given that K_a for HNO_2 is 5.0×10^{-4}, calculate the equilibrium constant for the reaction
$NO_2^- + H_2O \rightleftharpoons HNO_2 + OH^-$

[A] 5.0×10^{-4}

[B] 2.0×10^{-11}

[C] 2.0×10^{-4}

[D] 5.0×10^{10}

[E] 5.0×10^{18}

14. The ionization constant of water at 60°C is 9.2×10^{-14}. What is the pH of pure water at this temperature?
$H_2O \rightleftharpoons H^+(aq) + OH^-(aq)$

[A] 5.5

[B] 6.0

[C] 6.5

[D] 7.0

[E] 7.5

15. In a 0.10 M solution of sodium hydrogen sulfate, the HSO_4^- ion is 29% dissociated. The equilibrium constant for this acid is

[A] 8.4×10^{-3}.

[B] 1.0×10^{-2}.

[C] 1.2×10^{-2}.

[D] 2.0×10^{-2}.

[E] 2.4×10^{-1}.

Multiple Choice Questions: **1 mark each.**
Fill in all answers on the TRS form. Answers on the TRS form are considered Final.

16. The equilibrium constant at 1300 K for the reaction $H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$ is 1.6×10^5. The value of K for $HBr(g) \rightleftharpoons 1/2\ H_2(g) + 1/2\ Br_2(g)$ is

$2HBr_{(g)} \rightleftharpoons H_{2(g)} + Br_{2(g)}$

[A] 6.3×10^{-6}.

[B] 2.5×10^{-3}.

[C] -1.6×10^{5}.

[D] 2.5×10^{3}.

[E] 1.6×10^{-5}.

17. Calcium nitrate will react with ammonium chloride at slightly elevated temperatures, as represented in the equation

$Ca(NO_3)_2(s) + 2NH_4Cl(s) \longrightarrow 2N_2O(g) + CaCl_2(s) + 4H_2O(g)$

A 3.00-mol sample of each reactant will give what volume of N_2O at STP?

[A] 11.2 L

[B] 22.4 L

[C] 33.6 L

[D] 44.8 L

[E] 67.2 L

18. The equilibrium constant for the reaction

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

is 62.5 at 800 K. What is the equilibrium concentration of I_2 if [HI] = 0.20 M and $[H_2]$ = 0.10 M?

[A] 8.0×10^{-4} M

[B] 6.4×10^{-3} M

[C] 0.20 M

[D] 0.10 M

[E] 3.2×10^{-2} M

Multiple Choice Questions: **1 mark each.**
Fill in all answers on the TRS form. Answers on the TRS form are considered Final.

19. For an acetic acid–sodium acetate buffer solution to have a pH of 4.97, what molar ratio of CH_3COOH to $NaCH_3COO$ is needed (K_a for CH_3COOH is 1.8×10^{-5})?

[A] 0.60
[B] 0.8
[C] 1.2
[D] 1.7
[E] 2.0

$\Rightarrow 4.97 = -\log(1.8\times10^{-5}) + \log\left(\frac{\text{base}}{\text{acid}}\right)$

$\Rightarrow 4.97 = 4.744 + \log\left(\frac{\text{base}}{\text{acid}}\right)$

$\Rightarrow \frac{\text{base}}{\text{acid}} = 10^{(4.97-4.744)} = 1.68 \sim 1.7$

20. In the reversible reaction
$HCOO^-(aq) + H_2O(l) \rightleftharpoons HCOOH(aq) + OH^-(aq)$
which are the Brønsted acids?

[A] H_2O, HCOOH, and OH^-
[B] H_2O and OH^-
[C] H_2O and HCOOH
[D] $HCOO^-$ and HCOOH
[E] $HCOO^-$ and OH^-

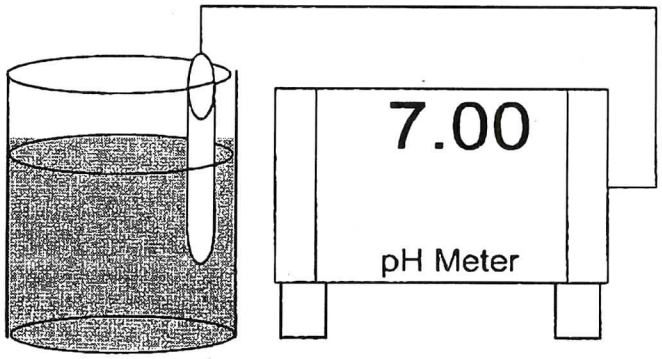
21. Which of the following samples has the least moles of gas?

[A] 1.00 L of NH_3 at STP — 0.0446
[B] 1.00 L of HCl at 20°C and 1.00 atm — 0.0415
[C] 1.00 L of H_2 at 0.0°C and 1.10 atm — 0.0490
[D] 1.00 L of Ar at –10.0°C and 1.00 atm — 0.0463
[E] 1.00 L of CH_4 at STP — 0.0446

$n = \frac{PV}{RT}$

Multiple Choice Questions: **1 mark each.**
Fill in all answers on the TRS form. Answers on the TRS form are considered Final.

22. Which salt, KCl, Na_2CO_3, NH_4Cl, RbF, or $Zn(NO_3)_2$, is most likely to form an aqueous solution having the pH shown in figure B?



[A] KCl

[B] Na_2CO_3

[C] NH_4Cl

[D] RbF

[E] $Zn(NO_3)_2$

23. For the reaction system $2CO_2(g) + N_2(g) + \text{heat} \rightleftharpoons 2NO(g) + 2CO(g)$, the conditions that favor maximum conversion of the reactants to products are

[A] low temperature and high pressure.

[B] low temperature and low pressure.

[C] high temperature and low pressure.

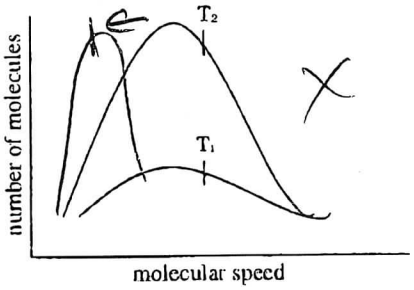
[D] high temperature and high pressure.

[E] high temperature, pressure being unimportant.

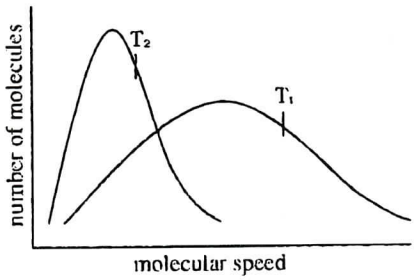
Multiple Choice Questions: **1 mark each.**
Fill in all answers on the TRS form. Answers on the TRS form are considered Final.

24. Molecular speed distributions for a gas at two different temperatures are shown below. Which of the following graphs correctly describes the distributions at the two temperatures, where $T_2 > T_1$? NOTE: the small vertical lines indicate average speed.

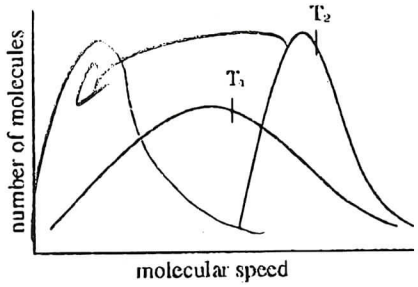
[A]



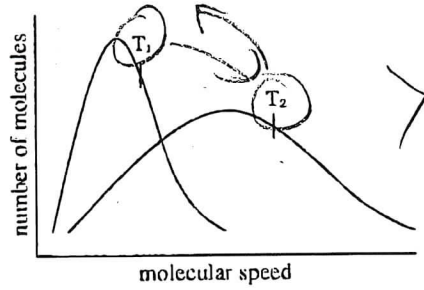
[B]



[C]



[D]



[E] none of the above.