OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA
DEPARTMENT OF CHEMISTRY
B.Sc. Degree (Chemistry) Examination Part II
CHM 203: Basic Physical Chemistry
Harmattan Mid-Semester Examination 2019/2020 Session

Instructions
Attempt all questions.

Time Allowed: 1 Hour

Constants: $R = 8.314\ J\ mol^{-1}\ K^{-1}$; $k_B = 1.385 \times 10^{-23}\ J\ K^{-1}$; Avogadro's number $= 6.022 \times 10^{23}$ molecules; $\pi = 3.142$; $O_2 = 32\ g.mol^{-1}$, $CH_4 = 16\ g.mol^{-1}$

Date: 12th November, 2022

TYPE 4

1. Which of the following is a state function and also an extensive property?

   A. Internal energy
   B. Pressure
   C. Molar heat capacity
   D. Temperature

2. A sample of liquid in a thermally insulated container (a calorimeter) is stirred by a motor. Taking liquid as a system for this process choose the appropriate option :
   A. $w < 0$; $q = 0$; $U = 0$
   B. $w > 0$; $q > 0$; $U > 0$
   C. $w < 0$; $q > 0$; $U = 0$
   D. $w > 0$; $q = 0$; $U > 0$

3. An ideal gas is taken around the cycle ABCA as shown in the P-V diagram below. The net work done by the gas during the cycle is equal to:

   A. $12\ P_1V_1$ B. $6P_1V_1$ C. $5P_1V_1$ D. P_1V_1

4. 16 g of oxygen gas expands isothermally and reversibly at 300 K from 10 dm³ to 100 dm³. The work done (in J) is
   A. zero   B. $-2875\ J$
   C. $+2875\ J$ D. infinite

5. Which of the following conditions is not favourable for the feasibility of a process ?

   A. $\Delta H = -ve$, $T\Delta S = -ve$ and $T\Delta S < \Delta H$

   B. $\Delta H = +ve$, $T\Delta S = +ve$ and $T\Delta S > \Delta H$

   C. $\Delta H = -ve$, $T\Delta S = +ve$ and $\Delta H > T\Delta S$

   D. $\Delta H = +ve$, $T\Delta S = +ve$ and $\Delta H > T\Delta S$

6. The root-mean-square velocity (v_{rms}) of oxygen gas at 298 K and 1.00 atm is 482 ms⁻¹ and the mean free path (λ) is 7.10×10^{-8} m. Calculate the average time (Δt) between collisions.
   A. $1.47 \times 10^{-10}\ s$ B. $6.79 \times 10^9\ s$
   C. $3.42 \times 10^{-5}\ s$ D. $4.39 \times 10^{-8}\ s$

7. At 298 K, the mean speed (v_{ms}) of a methane molecule is 628 m s⁻¹, the collision diameter (d) is 4.09×10^{-10} m, and the number density (N/V) is 2.43×10^{25} m⁻³. What is the collision frequency (Z_1)?
   A. $5.65 \times 10^9\ collision\ m^{-3}s^{-1}$
   B. $2.76 \times 10^{19}\ collision\ s^{-1}$
   C. $1.13 \times 10^{10}\ collision\ s^{-1}$
   D. $1.37 \times 10^{35}\ collision\ m^{-3}\ s^{-1}$

8. What is the most probable speed (v_{mp}) for oxygen gas at 298 K?
   A. $444\ m\ s^{-1}$ B. $393\ m\ s^{-1}$
   C. $482\ m\ s^{-1}$ D. $398\ m\ s^{-1}$

9. One mole of methane (CH_4) is confined to a 250 mL container at 300 K. Using van der Waal's equation, calculate its pressure. Given that $a = 2.253$ L^2 atm mol^{-2}; $b = 0.0428$ L mol^{-1}; $R = 0.0821$ L atm mol^{-1} K^{-1}.
A. 106.9 atm   B. 93.0 atm
C. 82.8 atm   D. 98.5 atm

10. The mean free path (λ) for a gas, with molecular diameter d and number density n, can be expressed as:

A. $\dfrac{1}{(\sqrt{2})n\pi d^2}$ B. $\dfrac{1}{(\sqrt{2})n^2\pi d^2}$

C. $\dfrac{1}{(\sqrt{2})n^2\pi^2 d^2}$ D. $\dfrac{1}{(\sqrt{2})n\pi d}$

11. For the reaction: $C_{(s)} + O_{2(g)} \rightarrow$ $CO_{2(g)}$
A. $\Delta H < \Delta U$ B. $\Delta H > \Delta U$
C. $\Delta H = \Delta U$ D. $\Delta H = 0$
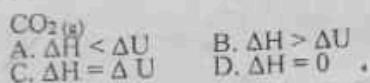
12. One mole of an ideal gas expands reversibly and adiabatically from a temperature of 27°C. If the work done during the process is 3 kJ, then final temperature of the gas is: (C_v = 20 J/K)
A. 100 K   B. 150 K
C. 450 K   D. 255 K

13. If $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O + x$ kJ
$H^+ + OH^- \rightarrow H_2O + y$ kJ
The enthalpy change for the reaction:
$CH_3COOH \rightarrow CH_3COO^- + H^+$ is

A. $x + y$ B. $x - y$

C. $y - x$ D. $x - y/2$

14. If the enthalpy of vaporisation of water is 186.5 J mol^{-1}, the entropy of its vaporisation will be
A. 0.5 JK^{-1} mol^{-1} B. 1.0 JK^{-1} mol^{-1}
C. 1.5 JK^{-1} mol^{-1} D. 1.865 JK^{-1} mol^{-1}

15. An ideal gas expands in volume from 1×10^{-3} m^3 to 1×10^{-2} m^3 at 300 K against a constant pressure 1×10^5 Nm^{-2}. The work done is
A. -900 J   B. 900 kJ
C. 270 kJ   D. 900 J

16. The overall rate, $+\dfrac{d[P]}{dt}$, for the reaction: $2A + C \rightarrow P$, the proposed mechanism is as follows

$2A \xrightleftharpoons{K} B$

$B + C \xrightarrow{k_f} P$
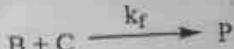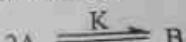
Where K = equilibrium constant and k_f = forward rate constant for the second step. The overall rate law consistent with the mechanism is

A. $\dfrac{d[P]}{dt} = Kk_f[A]^2[C]$

B. $\dfrac{d[P]}{dt} = K[A][B]$

C. $\dfrac{d[P]}{dt} = k_f[B][C]$

D. $\dfrac{d[P]}{dt} = Kk_f[A]^2[B][C]$

17. For the reaction:

$A \xrightarrow{k_1} B \xrightarrow{k_2} C \xrightarrow{k_3} D$

Given that $k_3 < k_2 < k_1$; the rate of formation of D is determined by
A. the rate of reaction: $A \rightarrow B$
B. the rate of reaction: $B \rightarrow C$
C. the rate reaction: $C \rightarrow D$
D. the rate of reaction: $A \rightarrow B$ with rate constant $k_1 \times k_2 \times k_3$

18. For a given reaction, the concentration of the reactant plotted

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against time gave a straight line with negative slope. The order of the reaction is

   A. 3
   B. 2
   C. 1
   D. 0

19. In a first-order reaction, the activity of reactant drops from 800 mol/L to 50 mol/L in 2×10^4 s. The rate constant of the reaction in, s^{-1}, is

   A. 1.386×10^{-4}
   B. 1.386×10^{-3}
   C. 1.386×10^{-5}
   D. 5.0×10^3

20. It takes 40 min for the completion of 50% of the reaction: A → Products. For the completion of next 50% of the reaction, time taken is 80 min. The order of the reaction is

   A. 2
   B. 0
   C. 3
   D. 1

21. For a chemical reaction: X → Y, the rate of reaction increases by a factor 1.837 when the concentration of X increased by 1.5 times. The order of the reaction with respect to X is

   A. 1
   B. 1.5
   C. 2
   D. -1

22. The rate of a reaction may be expressed as:

$$+\frac{1}{2}\frac{d[C]}{dt} = -\frac{1}{3}\frac{d[D]}{dt} = +\frac{1}{4}\frac{d[A]}{dt} = -\frac{d[B]}{dt}$$

. The reaction is

   A. $4A + B \rightarrow 2C + 3D$
   B. $B + 3D \rightarrow 4A + 2C$
   C. $4A + 2C \rightarrow B + 3D$
   D. $2A + 3B \rightarrow 4C + D$
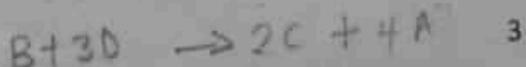
23. Which statement best describes the variation of the rate constant of a reaction with temperature?

   A. The rate constant does not change with temperature because it is an unvarying characteristic of the specific reaction.

   B. The rate constant typically decreases with increasing temperature because fewer molecules are able to adopt the required orientation at higher temperature.

   C. The rate constant typically increases with increasing temperature because increasing the temperature increases the fraction of collisions that result in reaction.

   D. The rate constant typically increases with increasing temperature because most reactions become more favorable as the temperature increases.

24. An irreversible reaction A + B → C is carried out under various conditions, but always with $[B]_0 \gg [A]_0$. Plots of 1/[A] as a function of time for each reaction are linear, and the slopes of these plots do not depend on the initial concentration of B. What is the rate law for the reaction under these conditions?

   A. Rate = k[A]
   B. Rate = k[A][B]
   C. Rate = k[A]²
   D. Rate = k[A]² [B]

25. What is the activation energy (in kJ) of a reaction whose rate constant

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increases by a factor of 100 upon increasing the temperature from 300 K to 360 K?
- A. 27
- B. 35
- C. 42
- D. 69

26. There are two statements about ideal gases
(i). The root-mean-square velocity, (V_{rms}), of gas molecules depends on the mass of the gas molecule and the temperature
(ii). The root-mean-square velocity, (V_{rms}), is same for all the gases at the same temperature.
Which one of the following options is/are correct?
- A. both (i) and (ii)
- B. (i) only
- C. (ii) only
- D. neither (i) nor (ii)

27. Choose the correct statement from the following
A. The pressure of the gas is equal to the total kinetic energy of the molecules in a unit volume of the gas
B. The product of pressure and volume of the gas is always constant
C. The average kinetic energy of molecule of the gas is proportional to its absolute temperature
D. The average Kinetic energy of molecule of the gas is proportional to the square root of its absolute temperature

28. Consider the following statements about gases:
(i). The attractive forces between the molecules is not negligible
(ii). Volume of the molecules is negligible as compared to the volume occupied by the gas

(iii). Volume of the molecules is not negligible as compared to the volume occupied by the gas
(iv). The attractive forces between the molecules is negligible
Which one of the statements is/are true according to van der Waals gas equation?
- A. (i) and (iii) only
- B. (ii) and (iv) only
- C. (i) and (ii) only
- D. (iii) and (iv) only

29. A gas behaves as an ideal gas at
- A. Low pressure and high temperature
- B. Low pressure and low temperature
- C. High pressure and low temperature
- D. High pressure and high temperature

30. The temperature of a gas is held constant, while its volume is decreased. The pressure exerted by the gas on the wall of the container increases, because its molecules
- A. Strike the walls with higher velocities
- B. Strike the walls with large farce
- C. Strike the walls more frequently
- D. Are in contact with the walls for a shorter time