Important Questions on Physical Chemistry

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1. A cricket ball has a weight of 100 g is located within 1 nm. Determine the uncertainty in the velocity.
A. 5.27×10^{-23} m/s
B. 5.27×10^{-25} m/s
C. 5.27×10^{-24} m/s
D. 5.27×10^{-27} m/s

2. The extent of dissociation of PCl_5 at a certain temperature is 20% at one atm pressure. Calculate the pressure at which this substance is half-dissociated at the same temperature.
A. 0.123
B. 0.389
C. 0.423
D. 0.789

3. KNO_3 crystallizes in an orthorhombic system with the unit cell dimensions *a* = 542 pm, *b* = 917 pm and *c* = 645 pm. Calculate the diffraction angles for first order X-ray reflections from 100 planes using radiation with wavelength = 154.1 pm.
A. $8^0 10'$
B. $9^0 20'$
C. $4^0 40'$
D. $3^0 30'$

4. Determine the temperature at which the average velocity of oxygen equals that of hydrogen at 20 K.
A. 420 K
B. 300 K
C. 320 K
D. 500 K

5. Acetaldehyde (CH_3CHO) decomposes by second-order kinetics with a rate constant of 0.334 $M^{-1}\ s^{-1}$ at 500°C. The time it would take for 80% of the acetaldehyde to decompose in a sample that has an initial concentration of 0.00750 M is
A. ~ 1600 sec
B. ~ 1850 sec
C. ~ 1000 sec
D. ~ 5100 sec

6. The time for which the oxygen atom remains adsorbed on a tungsten surface is 0.36 s at 2550 K and 3.49 s at 2360 K. Determine the activation of desorption of oxygen atom.
A. 432.42 kJ/mol
B. 532.30 kJ/mol
C. 326.43 kJ/mol
D. 598.29 kJ/mol

7. For a homogeneous gaseous reaction,
$SO_2Cl_2 \rightarrow SO_2 + Cl_2$
that obeys first order reaction, the half-life is 8.0 minutes. How long will it take for the concentration of SO_2Cl_2 to be reduced to 1% of the initial value?
A. 46.92 min
B. 52.93 min
C. 32.61 min
D. 23.43 min

8. At what wavelength in Å would the anti-stokes line appear in the Raman spectrum of the sample excited by the 4358 Å line of mercury. A Raman line was observed at 4447 Å.
A. 6238
B. 4272
C. 5678
D. 3456

9. Determine the molar solubility of $Zn(OH)_2$ in 1 M ammonia solution at room temperature. $K_{sp}(Zn(OH)_2) = 1.8 \times 10^{-17}; K_{stab}\text{of}[Zn(NH_3)_4]^{2+} = 1.64 \times 10^{10}$.
A. 4.19×10^{-4}
B. 4.19×10^{-5}
C. 4.19×10^{-6}
D. 4.19×10^{-3}

10. Point group which is both polar and optically active is:
A. C_i
B. C_s
C. C_1
D. C_{2v}

Answer Key

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

Solutions

Solution 1:

According to uncertainty principle

$$\Delta x \,.\, m\Delta v = \frac{h}{4\pi} \text{ or } \Delta v = \frac{h}{4\pi \times m \times \Delta x}$$

$$h = 6.626 \times 10^{-34}\,kgm^2s^{-1}, m = 100g = 0.1kg, \Delta x = 1nm = 10^{-9}m, \pi = 3.143$$

$$\Delta v = \left[\frac{(6.626 \times 10^{-34}\,kgm^2s^{-1}}{4 \times 3.143 \times x(0.1kg)(10^{-9}m)}\right] = 5.27 \times 10^{-25}\,ms^{-1}$$

Solution 2:

$K_p = \alpha^2P/(1 - \alpha^2)$

P = 1 atm, α = 0.2

∴ $K_p = (0.2)^2$ (1 atm) / (1 – 0.04) = 0.041 atm

Let P' be the pressure at which α = 0.5, then

$K_p = \alpha^2P'/(1 - \alpha^2)$

0.041 atm = $(0.5)^2P'/(1 - 0.25)$

P = 0.123 atm

Solution 3:

Bragg's equation is:

$2d_{hkl} \sin \theta = n\lambda$

For an orthorhombic system,

$1/(d_{hkl})^2 = (h^2/a^2) + (k^2/b^2) + (l^2/c^2)$

∴ $1/(d_{100})^2 = (1/542 \text{ pm})^2 + (0/917 \text{ pm})^2 + (0/645 \text{ pm})^2 = (1/542 \text{ pm})^2$

∴ $d_{100} = a$ = 542 pm

For first order reflection, n = 1.

Also,

λ = 154.1 pm

$\therefore \sin\theta_{100} = \frac{\lambda}{2d_{100}} = \frac{154.1 \text{ pm}}{2 \times 542 \text{ pm}} = 0.142$ where $\theta_{100} = 8°10'$

Solution 4. The expression to calculate average velocity is:

<c> = $(8RT/\pi M)^{1/2}$, i.e., <c> ∝ $(T/M)^{1/2}$

Let $\langle c\rangle_1$ and $\langle c\rangle_2$ be the average velocities of O_2 and H_2, respectively.

$\frac{\langle c\rangle_1}{\langle c\rangle_2} = \left(\frac{T_1/M_1}{T_2/M_2}\right)^{1/2} = 1$ so that $T_1/M_1 = T_2/M_2$

$T_1/32 \text{ g mol}^{-1} = T_2/2 \text{ g mol}^{-1}$

∴ $T_1 = (32/2)T_2 = 16 \times 20$ K = 320 K

Solution 5:
k = 0.334 $m^{-1}s^{-1}$

$$kt = \frac{1}{(a-x)} - \frac{1}{a}$$

$$t = \frac{1}{k}\left[\frac{1}{a-0.8a} - \frac{1}{a}\right] = \frac{1}{ka}\left[\frac{1}{2} - 1\right]$$

$$t = \frac{4}{ka} = \frac{4}{0.034 \times 0.0075}$$ = 1596.8 ≈ 1600 sec

Solution 6:
The expression to calculate desorption of oxygen atom is:

$$E_a = \frac{R\ln(\tau_2/\tau_1)(T_1T_2)}{T_1 - T_2}$$

$$= \frac{(8.314\ J\,K^{-1}\,mol^{-1})\ln(3.49\,s/0.36s)(2550\,K)(2360\,K)}{(2550-2360)\,K}$$

= 598.29 kJ mol^{-1}

Solution 7:
For first order kinetics, half-life is given by:

$$k_1 = -\frac{0.693}{t_{1/2}} = \frac{0.693}{8.0 min\ min^{-1}}$$

For a first-order reaction,

$$k_1 = \frac{1}{t} ln \frac{a}{a-x}$$

Or,

$$t = \frac{1}{k_1} ln \frac{a}{a-x} = \frac{1}{0.087\,min^{-1}} ln\left(\frac{100}{1}\right) = 52.93 min$$

Solution 8: The anti-Stokes line will appear at a frequency 460 cm^{-1} higher than the frequency (in cm^{-1}) associated with the 4358 Å Hg line used as a source of excitation. Now,

$$\bar{v}_{exc}(cm^{-1}) = \frac{10^8}{\lambda_{exc}(Å)} = \frac{10^8}{4.358 \times 10^3} = 2.295 \times 10^4 \ cm^{-1}$$

Hence, $\bar{v}_{anti\text{-}stokes}$ = $(2.295 \times 10^4\ cm^{-1}) + (460\ cm^{-1})$ = 2.341 × 104 cm^{-1}

$$\therefore\ \lambda\,(\text{in } Å) = \frac{10^8}{\bar{v}(cm^{-1})} = \frac{10^8}{2.341 \times 10^4} = 4272\ Å$$

Solution 9:
The solubility equilibrium in this case is represented as:

$$Zn(OH)_2(s) \rightleftarrows Zn^{2+}(aq) + 2OH^-(aq)$$

$$K_{sp} = [Zn^{2+}][OH^-]^2 = 1.18 \times 10^{-17}$$

(ii). $Zn^{2+} + 4NH_3(aq) \rightleftarrows [Zn(NH_3)_4]^{2+}$

$$K_{sab} = \frac{[Zn(NH_3)_4]^{2+}}{[Zn^{2+}][NH_3]^4}$$

The overall reaction is obtained by adding reactions (i) and (ii) as:

$$Zn(OH)_2(s) + \underset{1-4x}{4NH_3(aq)} \rightleftarrows \underset{x}{[Zn(NH_3)_4]^{2+}} + \underset{2x}{2OH^-(aq)}$$

$$K_{eq} = \frac{[Zn(NH_3)_4]^{2+}[OH^-]^2}{[NH_3]^4} = \frac{[Zn^{2+}][OH^-]^2[Zn(NH_3)_4]^{2+}}{[Zn^{2+}][NH_3]^4} = K_{sp}K_{stab}$$

If x is the molar solubility of $Zn(OH)_2$ in 1 M NH_2 solution, then at equilibrium,

$[NH_3] = 1 - 4x; [OH^-] = 2x and [Zn(NH_3)_4]^{2+} = x$

$K_{eq} = \frac{x(2x)^2}{(1-4x)^4} = 4x^3$ (since 4x << 1)

$4x^3 = K_{eq} = K_{sp}K_{stab} = (1.8 \times 10^{-17})(1.64 \times 10^{10})$

$x = 4.19 \times 10^{-3} mol dm^{-3}$

Solution 10:

For a point group which is to be both optically active and polar, it should not have any inversion centre. Ci cannot be the answer. The molecule should not have any sigma plane, otherwise the molecule will be asymmetric and asymmetric molecules are optically inactive, but they are polar molecules so, C_s and C_{2v} cannot be the answer because we need a point group which is not polar and optically inactive. So, according to this, c is the correct option.