Assiut University **September 2022**
Faculty of Science **Time: 3 hours**
Chemistry Department **Summer Semester**

Physical Chemistry III Examination (C-332)

Answer the following questions: (50 Marks)

Question One: Choose the correct answer for the following: (35 marks)

1. ..... successfully explained the blackbody radiation by assuming that energy is quantized.
   a) Planck b) De Broglie c) Einstein d) Schrödinger
2. In the photoelectric effect, the kinetic energy of ejected electrons is ..... the frequency of the incident light.
   a) dependent on b) inversely dependent on c) independent of
3. A wavefunction of a molecule has information about .....
   a) kinetic energy . b) potential energy c) dipole moment d) bond lengths
4. A particle in a one-dimensional box has ..... quantum number(s).
   a) **1** b) **2** c) **3** d) **4**
5. The energy of a particle on a sphere depends on quantum number(s) .....
   a) **l** b) $\mathbf{m_l}$ c) a and b
6. An electron in a hydrogen atom has ..... quantum number(s).
   a) **1** b) **2** c) **3** d) **4**
7. An electron in a helium atom has ....., quantum number(s).
   a) **1** b) **2** c) **3** d) **4**
8. For a hydrogen atom, the degeneracy of the level with $n = 2$ is .....
   a) **2** b) **4** c) **5** d) **9**
9. For a hydrogen atom, the degeneracy of the level with $l = 1$ is .....
   a) **3** b) **6** c) **7** d) **9**
10. The energy of an electrons in the $2P_x$ orbital of a hydrogen atom is ..... eV.
    a) **-13.6** b) **10.2** c) **-3.4** d) **-6.8**
11. ..... is the number of waves per unit distance.
    a) Wavelength b) Frequency c) Wavenumber
12. ..... has the highest energy.
    a) X-rays b) UV c) Visible region d) IR
13. A molecule has ..... energy.
    a) rotational b) vibrational c) electronic

14. The separation between the ..... energy levels is the highest.

a) rotational b) vibrational c) electronic

15. Electrons in free radicals can change their spin and give spectra called .....

a) ESR b) NMR c) UV-vis d) IR

16. ..... has a permanent dipole.

a) **HCl** b) **CO** c) **CO_2** d) Benzene

17. **CO_2** has ..... spectra.

a) rotational b) vibrational c) Raman

18. ..... show(s) rotational spectra.

a) **NO** b) **HCN** c) **N_2**

19. ..... has a center of symmetry.

a) **HCl** b) Acetylene c) Ethylene d) **CH_4**

20. ..... is symmetric top.

a) Benzene b) Ammonia c) Methyl chloride

21. ..... spectroscopy reveals the function groups in a molecule.

a) UV-vis b) IR c) Microwave d) Raman

22. ..... energy doesn't have a zero-point energy.

a) Rotational b) Vibrational c) a and b

23. Water has ..... bending mode(s) of vibration.

a) **1** b) **2** c) **3**

24. The stretching of ..... is IR active.

a) **H_2** b) **N_2** c) **Cl_2**

25. The stretching of ..... is Raman active.

a) **HCl** b) **O_2** c) **N_2**

26. **CCl_4** is ..... active.

a) IR b) microwave c) Raman

27. **$CHCl_3$** is ..... active.

a) IR b) microwave c) Raman

28. The symmetry of the atomic orbital(s) ..... is/are g.

a) **s** b) **p** c) **d** d) **f**

29. The possible electronic transition(s) in ethanol is/are .....

a) $\sigma \rightarrow \sigma^*$ b) $\pi \rightarrow \pi^*$ c) $n \rightarrow \sigma^*$ d) $n \rightarrow \pi^*$

30. The transition(s) ..... is/are symmetry forbidden.

a) $\sigma \rightarrow \sigma^*$ b) $\pi \rightarrow \pi^*$ c) $\pi \rightarrow \sigma^*$ d) $\sigma \rightarrow \pi^*$

31. An Auxochrome alters the ..... of absorption.

a) wavelength b) intensity c) a and b

32. .... shift is a shift toward a shorter wavelength.

a) Red b) Blue c) Hyperchromic d) Hypochromic

33. Assuming both molecules have the same bond length, the difference between the rotational spectral lines of ^{12}**CO** are ..... those of ^{13}**CO**.

a) greater than b) smaller than c) equal to

34. In fluorescence, the emitted light will have ..... wavelength compared to the absorbed light.

a) shorter b) longer c) the same

35. ..... is the slowest transition in this group.

a) Vibrational relaxation b) Fluorescence c) Phosphorescence d) Intersystem crossing

Question Two: Answer **ONLY THREE** of the following: (15 marks)

1) Derive the time-independent Schrödinger equation in one dimension.

2) Consider the operators $\frac{d}{dx}$ **and** $\frac{d^2}{dx^2}$.

Are $\psi_1(x) = A\sin\left(\frac{n\pi x}{\lambda}\right)$ and $\psi_2(x) = e^{kx}$ eigenfunctions of these operators? If yes, what are the eigen values? Note that A, n, λ, and k are constants.

3) For an electron moving on a ring:

a) Derive the solution for the Schrödinger equation.

b) Write down the expression for the energy. Is the energy quantized? What is the source of quantization (if any)?

c) What is the degeneracy of each energy level?

$$\nabla^2 = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial}{\partial\theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2}{\partial\phi^2}$$

4) The bond length of the **CO** molecule is **1.2 Å**. Calculate the separation between the rotational spectral lines in **cm^{-1}**.

C = 12.00, O = 15.9994, H = 1.67343 x 10^{-27} kg, c = 2.99793 x 10^8 ms^{-1}, h = 6.626 x 10^{-34} Js

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With My Best Wishes **Dr. Ahmed A. K. Mohammed**

Assiut University	**Summer Semester Final Examination**	
Faculty of Science	**in**	**Time : 3 Hours**
Department of Chemistry	**Inorganic Chemistry 2 (C-321)**	**September 2022**

Answer the following Questions: **(25 Marks)**

Question 1: Give the reason for the following:

1. Despite the 5d series consists of only ten elements, the atomic numbers of these elements vary from 57 for lanthanum (La) to 80 for mercury (Hg).
2. Unlike all metals, gold may exhibit the oxidation state (-1) in some compounds.
3. Zinc has the lowest melting point among the elements in the 3d series.
4. Co(II) gets easily oxidized to Co(III) when surrounded by strong field ligands.
5. The elements niobium $^{92}_{41}Nb$ and tantalum $^{181}_{73}Ta$ have the same size.
6. Cu(I) salts disproportionate in the aqueous media.
7. Iron has various ionic radii.

Question 2: Draw the crystal field orbital energy-level diagram and show the number of unpaired electrons in the complex anion $[Ni(CN)_4]^{2-}$.

Answer FIVE Questions only from the following: **(25 Marks)**

Question 3: Predict the maximum and minimum magnetic moment values for titanium in its compounds.

Question 4: Show the reason why transition elements tend to form alloys very readily and explain the main difference between the interstitial compounds and the alloys.

Question 5: Show the electron configuration and location of the element $_{24}X$ in the periodic table. Is this element likely to be an oxidizing or a reducing agent in aqueous media in its +2 oxidation state (why)?

Question 6: Show detailed procedures to balance the following equation.

$$MnO_4^- + Fe^{2+} \longrightarrow Mn^{2+} + Fe^{3+} \quad (H^+)$$

Question 7: Name the coordination compound $[(H_2O)_4Fe(\mu_2\text{-}OH)_2Fe(H_2O)_4](SO_4)_2$ and write the formula of sodium tetracyanonickelate(II).

Question 8: Define the terms "homoleptic and heteroleptic coordination compounds" and give an example for each.

Question 9: Describe, by an example for each, the *fac*- and *mer*-isomerism in the octahedral complexes.

Good Luck

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