

本試題允許考生使用計算機作答，並請使用答案卡由電腦閱卷。第四頁有週期表
請務必於答案卡上作答，違者該科不於計分。

單選題：本試題共有 40 題單選題，每題 2.5 分，總分為 100 分

- Which one is **covalent bonding**?
[A] π - π interaction, [B] van der Waals Interaction [C] Electrostatic interaction [D] Hydrogen Bond [E] C-F bond
- For H_2 , which of the following statements is **NOT** true?
[A] Its HOMO is the σ_{1s} orbital. [B] Its LUMO is the σ_{1s}^* orbital. [C] Its lowest-energy excited state electron configuration is $(\sigma_{1s})^1(\sigma_{1s}^*)^1$ [D] The bond order for Its lowest-energy excited state is **1** [E] Its ground state electron configuration is $(\sigma_{1s})^2$
- Name** the following structures: $CH_3-(CH_2)_6-CH_3$?
[A] pentane. [B] Hexane. [C] Heptane. [D] Octane. [E] Nonane
- For which of the following compound(s) are **cis** and **trans** isomers possible?
[A] 2,3-dimethyl-2-butene. [B] 3-methyl-2-pentene. [C] 4,4-dimethylcyclohexanol. [D] *ortho*-chlorotoluene. [E] All can exhibit *cis/trans* isomers
- How many **isomers** are there of "dichloroethene"?
[A] 2. [B] 3. [C] 4. [D] 5. [E] 6
- Which of the following is a **d^7** ion?
[A] Co(II). [B] Cu(II). [C] Mn(II). [D] Mn(IV). [E] Cu(I)
- The spectro-chemical series is $I^- < Br^- < Cl^- < F^- < OH^- < H_2O < NH_3 < en < NO_2^- < CN^-$ Which of the following complexes will absorb visible radiation of the **highest** energy (shortest wavelength)?
[A] $[Co(H_2O)_6]^{3+}$. [B] $[Co(I)_6]^{3-}$. [C] $[Co(OH)_6]^{3-}$. [D] $[Co(en)_3]^{3+}$. [E] $[Co(NH_3)_6]^{3+}$
- Which of the following complexes would be diamagnetic (all electrons paired)? Assume the **strong-field** case for all complexes.
[A] $[Ni(CN)_6]^{4-}$. [B] $[Ti(CN)_6]^{3-}$. [C] $[Co(CN)_6]^{3-}$. [D] $[Cr(CN)_6]^{3-}$. [E] none of these
- In which of the following compounds does N have its **maximum** oxidation state?
[A] NH_3 . [B] N_2O . [C] N_2 . [D] $NaNO_3$. [E] HN_3
- Cs-131 nuclide has a half-life of 30 years. After 144 years, about 3.0 grams remain. The original mass of the Cs-131 sample is closest to?
[A] 167 g. [B] 42 g. [C] 90g. [D] 292 g. [E] 100 g
- Which of the following is true for the cell shown here? $Zn(s) | Zn^{2+}(aq) || Cr^{3+}(aq) | Cr(s)$
[A] The electrons flow from the cathode to the anode. [B] The electrons flow from the zinc to the chromium.
[C] The electrons flow from the chromium to the zinc. [D] The chromium is oxidized. [E] The zinc is reduced.

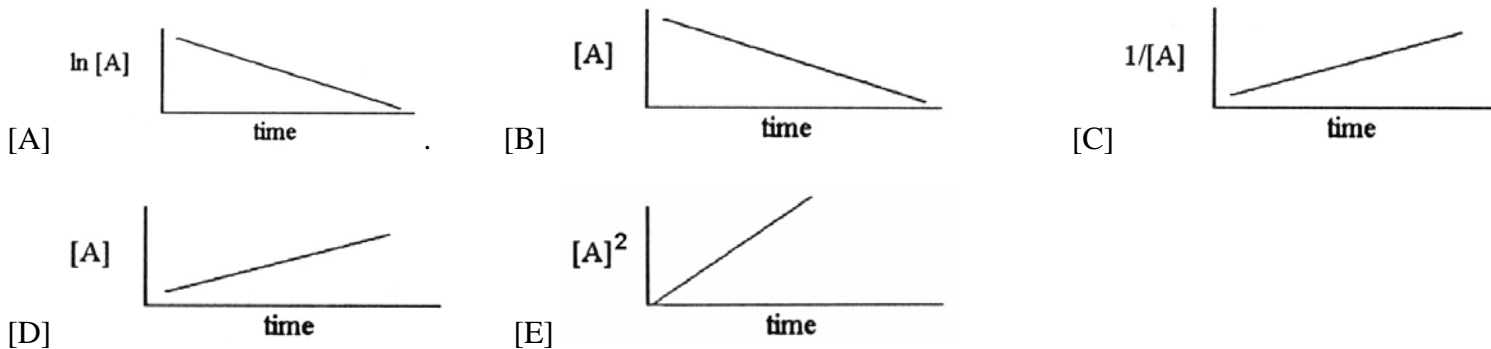
12. Consider an electrochemical cell with a zinc electrode immersed in 1.0 M Zn^{2+} and a silver electrode immersed in 1.0 M Ag^+ . $Zn^{2+} + 2e^- \rightarrow Zn$ $\epsilon^\circ = -0.755$ V; $Ag^+ + e^- \rightarrow Ag$ $\epsilon^\circ = 0.800$ V
Calculate the ϵ° for this cell?
[A] 0.045 V. [B] -0.045 V. [C] 1.555 V. [D] -1.555 V. [E] none of these
13. Which of the following would be the **BEST** oxidizing agent?
[A] Cl_2 . [B] Fe. [C] Na. [D] Na^+ . [E] F^-
14. For which of the following processes would ΔS be expected to be most **positive**?
[A] $O_2(g) + 2H_2(g) \rightarrow 2H_2O(g)$. [B] $H_2O(l) \rightarrow H_2O(s)$. [C] $NH_3(g) + HCl(g) \rightarrow NH_4Cl(g)$.
[D] $2NH_4NO_3(s) \rightarrow 2N_2(g) + O_2(g) + 4H_2O(g)$. [E] $N_2O_4(g) \rightarrow 2NO_2(g)$
15. Order the intermolecular forces (dipole-dipole (I), London dispersion (II), ionic (III), and hydrogen-bonding(IV)) from weakest to strongest.
[A] I<II<III<IV. [B] II<I<IV<III. [C] IV<I<II<III. [D] I<II<IV<III. [E] II<III<I<IV
16. A crystal was analyzed with x-rays having 1.57 Å wavelength. A reflection was produced at $\theta = 21.9$. Assuming $n = 1$, what is the distance between the layers of atoms in the crystal?
[A] 8.42 Å. [B] 4.21 Å. [C] 0.475 Å. [D] 0.846 Å. [E] 2.10 Å
17. Which one of the following statements about solid Cu (face-centered cubic unit cell) is **incorrect**?
[A] It will conduct electricity. [B] There are two atoms per unit cell. [C] The number of atoms surrounding each Cu atom is 12. [D] The solid has a cubic closest-packed structure. [E] The length of a face diagonal is four times the Cu radius.
18. The hybridization of the central atom in I_3^- is?
[A] sp . [B] sp^2 . [C] sp^3 . [D] dsp^3 . [E] d^2sp^3
19. A π (pi) bond is the result of the?
[A] overlap of two s orbitals. [B] overlap of an s orbital and a p orbital. [C] overlap of two p orbitals along their axes.
[D] sidewise overlap of two parallel p orbitals. [E] sidewise overlap of two s orbitals
20. Consider the following reaction? $A_2 + B_2 \rightarrow 2AB$ $\Delta H = 365$ kJ, The bond energy for A_2 is half the amount of AB . The bond energy of $B_2 = 447$ kJ/mol. What is the **bond energy** of A_2 (kJ/mol)?
[A] 812. [B] 630. [C] 271. [D] 183. [E] 120
- Consider the following molecules to answer **question 21, 22 and 23**
I. BF_3 II. $CHBr_3$ III. Br_2 IV. $XeCl_2$ V. CO VI. SF_4
21. Which of these molecules **violate** the octet rule?
[A] I, II, IV. [B] I, III, IV, VI. [C] III, V, VI. [D] I, IV, VI. [E] I, II, IV, VI
22. Which of these molecules have a **zero** net dipole moment.
[A] III, V. [B] I, III, IV. [C] III, IV, V. [D] I, III, IV, VI. [E] none of them
23. Which of these molecules have a **trigonal bipyramidal** electron pair arrangement?
[A] II, IV, VI. [B] I, IV. [C] IV, VI. [D] VI only. [E] none of them

24. How many of the following molecules or ions are **linear**?
- | | | | | |
|-------------------|-------------------|-------|-------------------|-----------------|
| NH ₃ , | OF ₂ , | HCN, | CO ₂ , | NO ₂ |
| [A]0. | [B]1. | [C]2. | [D]3. | [E]4 |
25. The energy of the light emitted when a hydrogen electron goes from $n = 2$ to $n = 1$ is what fraction of its ground-state ionization energy?
- | | | | | |
|---------|---------|---------|----------|------|
| [A]3/4. | [B]1/2. | [C]1/8. | [D]1/16. | [E]1 |
|---------|---------|---------|----------|------|
26. How many *f* orbitals have when $n=6$?
- | | | | | |
|-------|-------|--------|-------|-------|
| [A]2. | [B]7. | [C]10. | [D]5. | [E]18 |
|-------|-------|--------|-------|-------|
27. Which of the following atoms would have the **largest** second ionization energy?
- | | | | | |
|--------|--------|-------|--------|-------|
| [A]Mg. | [B]Cl. | [C]S. | [D]Ca. | [E]Na |
|--------|--------|-------|--------|-------|
28. A sample of He gas (3.0 L) at 5.6 atm and 25 °C was combined with 4.5 L of Ne gas at 3.6 atm and 25 °C at constant temperature in a 9.0 L flask. The total pressure in the flask was _____ atm. Assume the initial pressure in the flask was 0.00 atm and the temperature upon mixing was 25 °C?
- [A] 2.6 [B] 9.2. [C] 1.0. [D] 3.7. [E] 24
29. For which of the following transitions does the light emitted have the **longest** wavelength?
- [A] $n = 4$ to $n = 3$. [B] $n = 4$ to $n = 2$. [C] $n = 4$ to $n = 1$. [D] $n = 3$ to $n = 2$. [E] $n = 2$ to $n = 1$
30. Bromine exists naturally as a mixture of bromine-79 and bromine-81 isotopes. An atom of bromine-79 contains ?
- [A] 35 protons, 44 neutrons, 35 electrons. [B] 34 protons and 35 electrons, only. [C] 44 protons, 44 electrons, and 35 neutrons. [D] 35 protons, 79 neutrons, and 35 electrons. [E] 79 protons, 79 electrons, and 35 neutrons
31. How many grams of oxygen are in 0.52g of NaHCO₃?
- | | | | | |
|--------------|--------------|---------------------------|--------------|------------|
| [A] 0.099 g. | [B] 0.019 g. | [C] 6.19×10^3 g. | [D] 0.033 g. | [E] 0.30 g |
|--------------|--------------|---------------------------|--------------|------------|
32. In a given period this group has the element with the largest atomic **radius** ?
- | | | | | |
|---------------|---------------|---------------|---------------|--------------|
| [A] Group 1A. | [B] Group 2A. | [C] Group 3A. | [D] Group 4A. | [E] Group 5A |
|---------------|---------------|---------------|---------------|--------------|
33. An unknown salt, M₃Z, has a K_{sp} of 1.2×10^{-17} . Calculate the **solubility** in mol/L of M₃Z ?
- | | | | | |
|------------------------------|------------------------------|------------------------------|------------------------------|-----------------------|
| [A] $2.6 \times 10^{-5} M$. | [B] $3.5 \times 10^{-9} M$. | [C] $1.4 \times 10^{-6} M$. | [D] $2.2 \times 10^{-6} M$. | [E] none of the above |
|------------------------------|------------------------------|------------------------------|------------------------------|-----------------------|
34. Which of the following solid salts should be more soluble in 1.0 M NH₃ than in water?
- | | | | | |
|---------------------------------------|----------|-----------|------------------------|-------------------|
| [A] Na ₂ CO ₃ . | [B] KCl. | [C] AgBr. | [D] KNO ₃ . | [E] none of these |
|---------------------------------------|----------|-----------|------------------------|-------------------|
35. The properties of **graphene** include?
- | | | | | |
|--------------------|-------------------------------|------------------------|--------------|----------------|
| [A] high strength. | [B] low thermal conductivity. | [C] a zero energy gap. | [D] A and C. | [E] A, B and C |
|--------------------|-------------------------------|------------------------|--------------|----------------|
36. Which one of the following **vitamins** is water soluble?
- | | | | |
|-----------------|-----------------|-----------------|-----------------|
| [A] vitamins A. | [B] vitamins B. | [C] vitamins K. | [D] vitamins D. |
| [E] vitamins E | | | |

37. Which of the following is **NOT** classified as a nanomaterial?

- [A] isoprene. [B] C60. [C] carbon nanotubes. [D] graphene.
 [E] All of the above are nanomaterials

38. Which one of the following graphs shows the **correct** relationship between concentration and time for a reaction that is second order in [A] ?



39. How many chiral centers are there in $\text{CH}_3\text{CHClCH}_2\text{CH}_2\text{CHBrCH}_3$?

- [A]0. [B]1. [C]2. [D]3. [E]4

40. How many Department named “Medicinal and Applied Chemistry in Taiwan?”

- [A]0. [B]1. [C]2. [D]3. [E]4

Periodic Table of the Elements

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Atomic Number Symbol Name Atomic Mass </div>																			
1 IA 1A H Hydrogen (1.00794, 1.00811)	2 IIA 2A Be Beryllium (9.012182, 9.0121831)																		10 VIIIA 8A Ne Neon (19.99244, 19.992479)
3 IIIA 3A Li Lithium (6.941, 6.941)	4 IIIA 3A Be Beryllium (9.012182, 9.0121831)																	9 VIIA 7A F Fluorine (18.9984032, 18.9984032)	
11 IA 1A Na Sodium (22.98976928, 22.98976928)	12 IIA 2A Mg Magnesium (24.304, 24.304)																	17 VIIA 7A Cl Chlorine (35.453, 35.453)	
19 IA 1A K Potassium (39.0983, 39.0983)	20 IIA 2A Ca Calcium (40.078, 40.078)	21 IIIB 3B Sc Scandium (44.955912, 44.955912)	22 IIIB 3B Ti Titanium (47.88, 47.88)	23 IIIB 3B V Vanadium (50.9415, 50.9415)	24 IIIB 3B Cr Chromium (51.9961, 51.9961)	25 IIIB 3B Mn Manganese (54.938045, 54.938045)	26 IIIB 3B Fe Iron (55.845, 55.845)	27 IIIB 3B Co Cobalt (58.933195, 58.933195)	28 IIIB 3B Ni Nickel (58.6934, 58.6934)	29 IIIB 3B Cu Copper (63.546, 63.546)	30 IIIB 3B Zn Zinc (65.38, 65.38)	31 IIIB 3B Ga Gallium (69.723, 69.723)	32 IIIB 3B Ge Germanium (72.6305, 72.6305)	33 IIIB 3B As Arsenic (74.9216, 74.9216)	34 IIIB 3B Se Selenium (78.96, 78.96)	35 IIIB 3B Br Bromine (79.904, 79.904)	36 IIIB 3B Kr Krypton (83.798, 83.798)		
37 IA 1A Rb Rubidium (85.4678, 85.4678)	38 IIA 2A Sr Strontium (87.62, 87.62)	39 IIIB 3B Y Yttrium (88.90584, 88.90584)	40 IIIB 3B Zr Zirconium (91.224, 91.224)	41 IIIB 3B Nb Niobium (92.90638, 92.90638)	42 IIIB 3B Mo Molybdenum (95.94, 95.94)	43 IIIB 3B Tc Technetium (98)	44 IIIB 3B Ru Ruthenium (101.07, 101.07)	45 IIIB 3B Rh Rhodium (102.9055, 102.9055)	46 IIIB 3B Pd Palladium (106.42, 106.42)	47 IIIB 3B Ag Silver (107.8682, 107.8682)	48 IIIB 3B Cd Cadmium (112.411, 112.411)	49 IIIB 3B In Indium (114.818, 114.818)	50 IIIB 3B Sn Tin (118.710, 118.710)	51 IIIB 3B Sb Antimony (121.757, 121.757)	52 IIIB 3B Te Tellurium (127.6, 127.6)	53 IIIB 3B I Iodine (126.905, 126.905)	54 IIIB 3B Xe Xenon (131.29, 131.29)		
55 IA 1A Cs Cesium (132.90545196, 132.90545196)	56 IIA 2A Ba Barium (137.327, 137.327)	57-71 Lanthanide Series	72 IIIB 3B Hf Hafnium (178.49, 178.49)	73 IIIB 3B Ta Tantalum (180.94788, 180.94788)	74 IIIB 3B W Tungsten (183.84, 183.84)	75 IIIB 3B Re Rhenium (186.207, 186.207)	76 IIIB 3B Os Osmium (190.23, 190.23)	77 IIIB 3B Ir Iridium (192.222, 192.222)	78 IIIB 3B Pt Platinum (195.084, 195.084)	79 IIIB 3B Au Gold (196.966569, 196.966569)	80 IIIB 3B Hg Mercury (200.59, 200.59)	81 IIIB 3B Tl Thallium (204.3833, 204.3833)	82 IIIB 3B Pb Lead (207.2, 207.2)	83 IIIB 3B Bi Bismuth (208.9804, 208.9804)	84 IIIB 3B Po Polonium (209)	85 IIIB 3B At Astatine (210)	86 IIIB 3B Rn Radon (222)		
87 IA 1A Fr Francium (223)	88 IIA 2A Ra Radium (226)	89-103 Actinide Series	104 IIIB 3B Rf Rutherfordium (261)	105 IIIB 3B Db Dubnium (262)	106 IIIB 3B Sg Seaborgium (263)	107 IIIB 3B Bh Bohrium (264)	108 IIIB 3B Hs Hassium (265)	109 IIIB 3B Mt Meitnerium (266)	110 IIIB 3B Ds Darmstadtium (267)	111 IIIB 3B Rg Roentgenium (268)	112 IIIB 3B Cn Copernicium (269)	113 IIIB 3B Uut Ununtrium (270)	114 IIIB 3B Fl Flerovium (271)	115 IIIB 3B Uup Ununpentium (272)	116 IIIB 3B Lv Livermorium (273)	117 IIIB 3B Uus Ununseptium (274)	118 IIIB 3B Uuo Ununoctium (276)		

Constant	Symbol	Value
Atomic mass unit	amu	1.66054×10^{-27} kg
Avogadro's number	N	6.02214×10^{23} mol ⁻¹
Bohr radius	a_0	5.292×10^{-11} m
Boltzmann constant	k	1.38066×10^{-23} J/K
Charge of an electron	e	1.60218×10^{-19} C
Faraday constant	F	96.485 C/mol
Gas constant	R	8.31451 J/Kmol 0.08206 L · atm/K · mol
Mass of an electron	m_e	9.10939×10^{-31} kg 5.48580×10^{-4} amu
Mass of a neutron	m_n	1.67493×10^{-27} kg 1.00866 amu
Mass of a proton	m_p	1.67262×10^{-27} kg 1.00728 amu
Planck's constant	h	6.62608×10^{-34} J · s
Speed of light	c	2.99792458×10^8 m/s