Engineering Daily 14 [Set 04] EV

Periodic Properties of Elements and Chemical Bonding (Periodic Properties of Elements)

Total Marks: 50 **Negative Marks:** 0.25 **Time:** 1 Hour

MCQ 50 marks

1. The quantum numbers of the last electron of an element Z are $n = 3, l = 1, m = +1, s = +\frac{1}{2}$. Which element is Z?

   (A) Si (14) (B) Al (13)

   (C) Mg (12) (D) P (15)

2. Element W's M shell (3rd principal energy level) is completely full with 18 electrons, and its N shell has 1 electron. Which element is W?

   (A) Cr (Z = 24) (B) Cu (Z = 29)

   (C) Ga (Z = 31) (D) K (Z = 19)

3. Which of the following sets of quantum numbers is possible for two electrons in the same orbital?

   (A) $(3, 2, -1, +\frac{1}{2})$ and $(3, 2, -1, -\frac{1}{2})$

   (B) $(2, 1, 0, +\frac{1}{2})$ and $(3, 1, 0, +\frac{1}{2})$

   (C) $(3, 2, -1, +\frac{1}{2})$ and $(3, 2, 0, +\frac{1}{2})$

   (D) $(2, 0, 0, +\frac{1}{2})$ and $(2, 1, 0, +\frac{1}{2})$

4. A cation M^{2+} has the configuration $[Ar]3d^3$. What is the full electron configuration of the parent metal M, and which element is it?

   (A) $[Ar]3d^3 4s^2$, V (B) $[Ar]3d^1 4s^2$, Sc

   (C) $[Ar]3d^2 4s^2$, Ti (D) $[Ar]3d^5 4s^0$, Mn

5. By Slater's rule, the effective nuclear charge on Sc's (Z = 21, $[Ar]3d^1 4s^2$) $3d^1$ electron is comparatively low. Which observation does this help explain?

   (A) Why Sc has no ionization energy

   (B) Why 4s electrons are removed first

   (C) Why Sc is a noble gas

   (D) Why Sc^{3+} cannot form

6. Which of the following configurations is a possible ground state, not an excited one?

   (A) $1s^2 2s^1 2p^7$ (B) $1s^2 2p^2$

   (C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ (D) $1s^2 2s^2 2p^5 3s^1$

7. A +3 ion has 3 unpaired electrons in its 3d subshell ($3d^3$, all singly occupied). What is the possible atomic number of the parent metal M?

   (A) Z = 25 (Mn) (B) Z = 23 (V)

   (C) Z = 24 (Cr) (D) Z = 26 (Fe)

8. An element's E_3/E_2 ratio is normal (2-3×), but E_1 is unusually low and E_1/E_2 is very small (about 0.1). Which group could the element belong to?

   (A) Group 14 (B) Group 16

   (C) Group 18 (D) Group 1

9. By the (n + l) rule, what is the correct increasing order of energy for the 6s, 4f, 5d orbitals?

   (A) 6s < 5d < 4f (B) 4f < 6s < 5d

   (C) 6s < 4f < 5d (D) 5d < 6s < 4f

10. Ag's (Z = 47, $[Kr]4d^{10}5s^1$) comparatively low ionization energy has the same cause as Cu's — which is the correct explanation?

    (A) Ag is a noble gas

    (B) Ag's Z_{eff} is the highest

    (C) The filled $4d^{10}$ effectively screens $5s^1$

    (D) Because 4d is incomplete

11. An element has 5 valence electrons located in the n = 4 shell. Why is a huge jump expected in its sixth ionization energy?

    (A) After removing 5, removal starts from the inner n = 3 shell

    (B) Because the element is a noble gas

    (C) Because the number of valence electrons should be 6

    (D) No jump is expected

12. An element has $E_1 = 899, E_2 = 1757, E_3 = 14849\ kJmol^{-1}$. What is the element's group and likely oxidation number?

    (A) Group 3, +3 (B) Group 13, +3

    (C) Group 2, +2 (D) Group 1, +1

13. The E_1 values of period-2 elements Li, Be, B, C are, in scrambled order (kJ/mol), 801, 1086, 520, 899. Match them correctly.

    (A) Li = 520, Be = 899, B = 801, C = 1086

    (B) Li = 801, Be = 520, B = 899, C = 1086

    (C) Li = 899, Be = 520, B = 801, C = 1086

    (D) Li = 520, Be = 801, B = 899, C = 1086

14. An element has $E_1 = 1000, E_2 = 2260, E_3 = 3390\ kJmol^{-1}$ (normal increase, no jump in the first 3), but $E_4 = 4540$ keeps this trend, while $E_5 = 6950$ shows a slightly larger increase. Which group is the element likely in?

    (A) Group 2 (B) Group 15

    (C) Group 1 (D) Group 4

15. If E_1 is plotted for period-3 elements (Na → Ar), where will local dips appear?

    (A) Mg → Al and P → S

    (B) Na → Mg and Cl → Ar

    (C) Si → P and S → Cl

    (D) There will be no dip anywhere

16. Among an element's 6 successive IE values, a notable (but different-magnitude) increase occurs at both $E_1 \rightarrow E_2$ and $E_5 \rightarrow E_6$. Which scenario does this best match?

(A) The element is in Group 1

(B) The element is a noble gas

(C) It matches no scenario

(D) An ns^2np^4 configuration; the real jump is at E_7

17. A student claims, \"Na's E_2 and Mg's E_1 are close in value, because in both cases an electron is removed from 3s, and both the ion and atom have the same electron count (11).\" Evaluate the claim.

(A) Partly correct — not isoelectronic, but Na^+ = [Ne]'s structure is hard to break

(B) Completely correct

(C) Na's E_2 is actually much lower than Mg's E_1

(D) Completely wrong, no relationship

18. What is the correct order of first ionization energy for Si, P, S, and what is the exceptional reason for it?

(A) S > P > Si (perfectly smooth, no exception)

(B) All three are equal

(C) Si > P > S

(D) P > S > Si; stability of P's half-filled $3p^3$

19. In one successive-IE dataset (kJ/mol): E_1 = 1012, E_2 = 1903, E_3 = 2910, E_4 = 4956, E_5 = 6273, E_6 = 21269, E_7 = 25397. For a comparable Group 16 element (E_1 = 1000, E_2 = 2251, E_3 = 3361, E_4 = 4564, E_5 = 7013, E_6 = 8495, E_7 = 27107) — comparing where the jumps occur, which has more valence electrons?

(A) The first has more (B) Cannot be determined

(C) Equal for both (D) The second has more

20. Comparing E_2 for K and Ca, why will Ca's E_2 be much lower than K's E_2?

(A) Ca's size is larger than K's

(B) Both are equal

(C) K^+ = [Ar] but Ca^+ = $[Ar]4s^1$ (easily removed)

(D) K has more protons

21. Which pair of elements both have electron affinity near zero or positive, for the same structural reason (but in different groups)?

(A) N and Mn (B) O and S

(C) Na and K (D) F and Cl

22. An element's 4 successive IE values (kJ/mol) are 786, 1577, 3232, 4356 — no huge jump anywhere. What can be said about its number of valence electrons?

(A) At least 4 (B) Definitely 4 (C) 1 (D) 2

23. Among the noble gases, why is He's E_1 ($2372\ kJmol^{-1}$) the highest of any element?

(A) He has the most protons

(B) He's radius is the largest

(C) He is a radioactive element

(D) With the smallest shell and least screening, attraction is greatest

24. In Slater's rule, how much does each electron in the same $(n-1)$ shell contribute to the screening constant for an ns electron? How is this used to explain jumps in successive IE?

(A) 0; the inner shell gives no screening

(B) 1.00; no effect

(C) Slater's rule applies only to p electrons

(D) About 0.85; partial screening

25. In a hypothetical dataset, the ratio of the first 2 IE values (E_2/E_1) is only 1.2 (very close), which is unusually low. For which group's element is this least likely?

(A) Group 13 (B) Group 15

(C) Group 14 (D) Group 1

26. An element whose last electron has quantum numbers $n = 4, l = 0$ shows a huge jump at $E_2 \rightarrow E_3$. What is the element?

(A) Ca (Z = 20) (B) K (Z = 19)

(C) Ga (Z = 31) (D) Sc (Z = 21)

27. Comparing the electron affinities of Se and S, which is higher and why (compared with the O, S pair)?

(A) Cannot be determined

(B) Se > S, as an exception

(C) Equal

(D) S > Se (normal downward-decreasing trend)

28. Which statement is correct about the energy released forming Br^- and the nature of the (hypothetical) $Br \rightarrow Br^{2-}$ step?

(A) Br^{2-} is a stable ion

(B) Both steps are endothermic

(C) First exothermic, second endothermic

(D) Both steps are exothermic

29. An element Y has the configuration $[Ne]3s^23p^4$. What can be said about Y's second electron affinity ($Y^- \rightarrow Y^{2-}$), and in which common compound formation does this matter?

(A) Y^{2-} simply cannot form

(B) Zero

(C) Strongly positive (endothermic)

(D) Strongly negative (exothermic)

30. An element X has the configuration $[He]2s^2 2p^2$. What trend will X's electron affinity show compared to its neighbours B ($2p^1$) and N ($2p^3$)?

(A) Equal to both

(B) Lower than both

(C) Cannot be determined

(D) Higher than both B and N

31. F's electron affinity ($-328\ kJmol^{-1}$) is lower than Cl's ($-349\ kJmol^{-1}$), yet F's electronegativity is higher than Cl's (4.0 vs 3.0). What resolves this apparent contradiction?

(A) Cl's actual electron affinity should be lower than F's

(B) Two different properties, measured in different contexts

(C) F's actual electronegativity should be lower than Cl's

(D) It is a measurement error

32. What is the relationship between electron affinity and metallic character, and using this, which of Group 1 and Group 17 generally has the higher electron affinity?

(A) Group 17 (non-metal) exceeds Group 1

(B) Group 1's electron affinity is higher

(C) Electron affinity rises with metallic character too

(D) There is no relationship

33. Moving diagonally on the periodic table (upper-right to lower-left), what is the general trend in electron affinity, and between F and S, which is higher?

(A) By actual values, F > S (328 > 200)

(B) F will always be higher, no exceptions

(C) The relationship is impossible to determine

(D) S will always be higher

34. An element's measured electron affinity is found to be lower than expected even though it is the first member of its group. If this element is period-2, Group 16, what is the explanation?

(A) No exception occurs in Group 16

(B) It is a noble gas

(C) It is S; there is no exception

(D) It is O; small size causes greater electron repulsion

35. Regarding Slater screening and electron affinity, what is the general trend of electron affinity across a period, left to right (exceptions included)?

(A) It applies only to period 2, nowhere else

(B) Generally increases, but an exceptional dip also occurs

(C) It always decreases

(D) There is no trend

36. $S^{2-}, Cl^-, K^+, Ca^{2+}$ (all have 18 electrons, argon-like) — what is the correct decreasing order of their radii?

(A) All equal

(B) $Ca^{2+} > K^+ > Cl^- > S^{2-}$

(C) $S^{2-} > Cl^- > K^+ > Ca^{2+}$

(D) $Cl^- > S^{2-} > Ca^{2+} > K^+$

37. Nb (Z = 41) and Ta (Z = 73) have nearly equal atomic radii for the same reason as the Zr/Hf pair. Based on this, does the same reasoning apply to Sc (Z = 21) and Y (Z = 39), and why?

(A) Sc/Y 's radii are always equal

(B) Sc's radius is larger than Y 's

(C) Not applicable; there is no 4f series between Sc and Y

(D) Applicable, the same reason works for both pairs

38. Compare the hydrated radius and aqueous-solution conductivity of Na^+ and K^+.

(A) Na^+'s conductivity is higher

(B) Both have equal conductivity

(C) Na^+'s conductivity is lower than K^+'s

(D) K^+'s hydrated radius is larger

39. A diagonal relationship exists between B and Si. Using its quantitative basis ($\phi = z/r$), explain the reason for this relationship.

(A) B^{3+} and Si^{4+} have close ionic potential

(B) B and Si's sizes are exactly equal

(C) B and Si are in the same group

(D) There is no relationship — it's a common misconception

40. If Ar is added to a graph of covalent radii for period-3 elements (Na → Ar), will the same kind of anomaly as Ne appear? Explain.

(A) Ar's radius will be smaller than Cl's

(B) Ar has no measurable radius

(C) Yes, for the same reason (a van der Waals radius is used)

(D) No, there is no anomaly for Ar

41. What is the order of acidity for $H_3PO_4, H_3PO_3, H_3PO_2$ (phosphorus oxidation numbers +5, +3, +1), and what is the exceptional reason for it (if any)?

(A) $H_3PO_4 > H_3PO_3 > H_3PO_2$ (by the simple rule)

(B) The simple relationship doesn't hold — some H atoms bond directly to P

(C) All three are equally acidic

(D) Cannot be determined

42. In transition-metal ions, does the radius curvature caused by uneven t_{2g}/e_g filling matter more at d^3 or d^8? And why do these two create local minima in the radius curve?

(A) Most prominent at d^0 and d^{10}

(B) Both (d^3 and d^8); more electrons sit in t_{2g}

(C) Only prominent at d^5

(D) Not prominent in either

43. Compare the ionic radii of Cu^+ and Cu^{2+}, and comment on Cu^+'s unusual stability ($3d^{10}$, full).

(A) Cu^+ is more stable in aqueous solution

(B) Cu^+ is larger; Cu^{2+} is more stable via hydration

(C) Cu^{2+} is larger

(D) Both are equal

44. Due to the overall effect of lanthanide contraction, how does the density of period-6's d-block elements (after La) compare to their period-5 counterparts, and why?

(A) Equal

(B) Significantly higher (more mass in about the same volume)

(C) Cannot be determined

(D) Lower, because higher mass means lower density

45. Between Mn^{2+} ($3d^5$, half-filled) and Fe^{2+} ($3d^6$), which one's radius is likely to deviate more from the expected trend?

(A) Fe^{2+} (d^6); more deviation from the asymmetric configuration

(B) Neither deviates

(C) Mn^{2+} (d^5) deviates more

(D) Both deviate equally

46. Among metallic, covalent, and ionic radii, which applies to a cation of the same element, and how does it generally compare to the parent atom's radius?

(A) The metallic radius applies, and it's equal

(B) The covalent radius applies, and it's larger

(C) The ionic radius applies, and it's smaller than the parent atom

(D) The ionic radius applies, but it's larger than the parent atom

47. PbO is an amphoteric oxide. What will it produce when reacting with both HNO_3 and NaOH (with equations)?

(A) Reacts only with HNO_3

(B) Reacts only with NaOH

(C) Reacts with neither

(D) $PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$ and $PbO + 2NaOH \rightarrow Na_2PbO_2 + H_2O$

48. Do period-4's main-row oxides show the same basic-to-acidic trend as period 3?

(A) In period 4 all oxides are acidic

(B) Yes, the general principle applies to every period

(C) In period 4 all oxides are basic

(D) No, period 4 shows a completely different trend

49. Between SnO and SnO_2, which is more basic (less acidic), and why?

(A) Both are equally basic

(B) Both are fully acidic

(C) SnO_2 is more basic

(D) SnO is more basic, SnO_2 is more acidic

50. Between H_2SO_4 and H_2SeO_4 (both with central-atom oxidation number +6), which is the stronger acid?

(A) H_2SeO_4 is more acidic

(B) H_2SO_4 is more acidic (S is smaller)

(C) Cannot be compared

(D) Both are equally acidic