Engineering Daily 14 [Home Practice] 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 last electron of an element Q has quantum numbers $n = 3, l = 1, m = -1, s = +\frac{1}{2}$. If this is the first electron in the 3p subshell, what is Q?

   (A) Na ($Z = 11$) (B) Mg ($Z = 12$)

   (C) Al ($Z = 13$) (D) Si ($Z = 14$)

2. Element R's L shell (2nd shell) is completely full, and its M shell has 7 electrons. What is R?

   (A) S ($Z = 16$) (B) Ar ($Z = 18$)

   (C) P ($Z = 15$) (D) Cl ($Z = 17$)

3. Which of the following sets of quantum numbers would violate the Pauli Exclusion Principle if both were present in the same atom?

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

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

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

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

4. A cation M^{3+} has the configuration $[Ar]3d^5$. What is the full configuration and atomic number of the parent metal M?

   (A) $[Ar]3d^8 4s^0$, Ni

   (B) $[Ar]3d^5 4s^3$ (impossible configuration)

   (C) $[Ar]3d^6 4s^2$, Fe

   (D) $[Ar]3d^7 4s^1$, Co

5. According to Slater's rules, how does the screening contribution of the 4s electrons on the 3d electrons of Ti ($[Ar]3d^2 4s^2$) compare, and what is the result?

   (A) Since 3d electrons are outside 4s, the screening is zero

   (B) 4s electrons provide relatively good screening on 3d

   (C) 4s provides no screening at all

   (D) 4s screening is always weaker than 3d

6. Which of the following configurations is an impossible (invalid) configuration — not merely "excited" but structurally wrong?

   (A) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$ (B) $1s^2 2s^2 2p^6 3s^2 3p^6$

   (C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{11}$ (D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

7. Using the $(n + l)$ rule, determine the correct increasing order of energy for the 5f, 6d, 7s orbitals (actinide region).

   (A) 5f < 7s < 6d (B) 7s < 6d < 5f

   (C) 6d < 7s < 5f (D) 7s < 5f < 6d

8. Can Au's ($Z = 79$, $[Xe]4f^{14}5d^{10}6s^1$) low ionization energy be explained by exactly the same reasoning as Cu, Ag?

   (A) No, a completely different reason applies for Au

   (B) Au has no s electron

   (C) Au's ionization energy is actually the highest

   (D) Yes, the full $5d^{10}4f^{14}$ effectively screens $6s^1$

9. An element has 2 valence electrons located in the $n = 5$ shell. Why would a huge jump be expected in its third ionization energy?

   (A) Because it should have 3 valence electrons

   (B) After removing 2 electrons, removal will begin from the (inner) $n = 4$ shell

   (C) No jump is expected

   (D) Because the element is a halogen

10. A +2 ion has 7 electrons in its 3d subshell ($3d^7$). What is the atomic number of the parent metal?

    (A) $Z = 26$ (Fe) (B) $Z = 28$ (Ni)

    (C) $Z = 27$ (Co) (D) $Z = 25$ (Mn)

11. An element has $E_1 = 419$, $E_2 = 3051$ kJmol^{-1}. What is the element's group and oxidation number?

    (A) Group 13, +3 (B) Group 1, +1

    (C) Group 2, +2 (D) Group 17, −1

12. The E_1 values (in scrambled order) for period-3 elements Na, Mg, Al, Si are 786, 496, 738, 578 kJmol^{-1}. Match them correctly.

    (A) Na = 786, Mg = 496, Al = 578, Si = 738

    (B) Na = 578, Mg = 496, Al = 738, Si = 786

    (C) Na = 496, Mg = 578, Al = 738, Si = 786

    (D) Na = 496, Mg = 738, Al = 578, Si = 786

13. An element has $E_1 = 1000$, $E_2 = 2251$ kJmol^{-1}, but $E_3 = 3361$ kJmol^{-1} (no huge jump), and $E_4 = 4564$ maintains this pattern. What can be inferred as having happened at $E_5 = 7013$ kJmol^{-1}?

    (A) No conclusion can be reached

    (B) The element has already achieved a noble-gas structure

    (C) A partial jump begins at $E_4 \rightarrow E_5$; the element is likely Group 16

    (D) The element is Group 4

14. An element's E_1 to E_2 ratio is roughly 2 (normal), but E_3 is roughly 4 times E_2. How many valence electrons does the element have?

    (A) 1 (B) 4 (C) 3 (D) 2

15. If E_1 is plotted for the first 8 main-group elements of period 4 (K → Kr), what will the general trend be, and how does the presence of the d-block complicate this?

Ⓐ No complication occurs

Ⓑ Ga's E_1 will be the highest

Ⓒ An upward trend, but d-block complication appears at Ga

Ⓓ E_1 keeps decreasing steadily after crossing the d-block

16. Among an element's 7 successive IE values, the biggest jump occurs at $E_6 \rightarrow E_7$. What is the element's most likely oxidation number and group?

Ⓐ +4, Group 14 Ⓑ +5, Group 15

Ⓒ +6, Group 16 Ⓓ +7, Group 17

17. A student claims, "Since Ca^{2+} and K^+ are isoelectronic, their (neutral-atom) E_1 values should be equal." Where is the flaw in this claim?

Ⓐ E_1 is a property of the neutral atom; neutral Ca and K have different electron counts

Ⓑ The claim is correct

Ⓒ Only the part that Ca^{2+} and K^+ are not actually isoelectronic is wrong

Ⓓ E_1 only applies to ions

18. Explain the order of first ionization energies of As, Se and its reason (drawing an analogy with the N/O, P/S pattern).

Ⓐ Cannot be determined

Ⓑ $E_1(As) > E_1(Se)$; stability of the half-filled $4p^3$

Ⓒ $E_1(Se) > E_1(As)$, no exception

Ⓓ Both are equal

19. Successive IE data (kJ/mol): $E_1 = 590, E_2 = 1145, E_3 = 4912, E_4 = 6491, E_5 = 8153$ — compare this with another element's data ($E_1 = 633, E_2 = 1235, E_3 = 2389, E_4 = 7091$) and say which one has more valence electrons.

Ⓐ Cannot be determined

Ⓑ The first one has more

Ⓒ Equal

Ⓓ The second one has more

20. Which statement is correct about the energy released forming I^- and the nature of the $I \rightarrow I^{2-}$ step, and among the halogens, which has the lowest exothermicity in its first step?

Ⓐ F is the least exothermic; the 2nd step is endothermic

Ⓑ The first step is equal for all halogens

Ⓒ Both steps are exothermic

Ⓓ I's first step is endothermic

21. In Slater's rules, how much screening do electrons of the (n − 2) shell and below provide on ns electrons, and how does this help explain the "second jump" in successive IE?

Ⓐ The (n − 2) shell plays no role in screening

Ⓑ 0; no screening

Ⓒ 0.35; weak screening

Ⓓ Approximately 1.00 (complete screening)

22. Comparing E_2 of Rb, Sr, why will Sr's E_2 be much lower than Rb's E_2?

Ⓐ Both are equal

Ⓑ Sr's size is smaller than Rb's

Ⓒ Rb has more protons

Ⓓ Sr^+'s $5s^1$ is easily removed

23. An element's 3 successive IE values (kJ/mol) are 1012, 1903, 2910 — no huge jump anywhere. What is the minimum that can be said about the number of valence electrons?

Ⓐ At least 3 Ⓑ 1 Ⓒ Exactly 3 Ⓓ 5

24. Among the noble gases (except He), why is Ne's E_1 the highest (within Group 18)?

Ⓐ Ne has the most protons

Ⓑ Highest Z_{eff} at the smallest radius

Ⓒ Because Ne is radioactive

Ⓓ Ne has the fewest electrons

25. In a dataset, the E_3/E_2 ratio is very high (about 5), but the E_1/E_2 ratio is normal (about 2). For which group of elements is this pattern most likely?

Ⓐ Group 14 Ⓑ Group 2

Ⓒ Group 13 Ⓓ Group 1

26. An element with last-electron quantum numbers $n = 4, l = 1$ shows a huge jump at $E_5 \rightarrow E_6$ (5 valence electrons). What is the element?

Ⓐ Ge (Z = 32) Ⓑ As (Z = 33)

Ⓒ Se (Z = 34) Ⓓ Br (Z = 35)

27. Comparing the electron affinities of Te and Se, which one is higher (following the normal downward trend within Group 16)?

Ⓐ Cannot be determined Ⓑ Te > Se

Ⓒ Equal Ⓓ Se > Te

28. Using Slater's screening principle, explain why within Group 17, Cl's electron affinity is the highest, not F's (even though F has the highest Z_{eff}).

Ⓐ Cl's Z_{eff} is actually higher than F's

Ⓑ F's electron affinity is actually the highest

Ⓒ The screening principle doesn't apply here

Ⓓ Repulsion dominates due to F's small size

29. Why is P 's electron affinity ($-72\ \text{kJmol}^{-1}$) lower than both its neighbors Si (−134) and S (−200)?

(A) The stability of P 's half-filled $3p^3$ configuration

(B) P 's size is the smallest

(C) P is a metal

(D) P has the fewest protons

30. Which two elements' electron affinities are nearly zero or slightly negative for the same structural reason (a full subshell), despite being in different groups?

(A) Mg and Zn (B) Na and K

(C) F and Cl (D) O and S

31. An element Z has the configuration $[Ar]3d^{10}4s^24p^3$. Give an idea of Z's second electron affinity, and state which general group-level principle it is consistent with.

(A) Z^{2-} cannot form at all

(B) Strongly positive (endothermic)

(C) Zero

(D) Strongly negative

32. Using the relationship between electron affinity and nonmetallic character, argue which will have the (average) higher electron affinity between Group 16 and Group 14.

(A) Group 14 higher (B) Group 16 higher

(C) Equal (D) No relationship

33. An element X has the configuration $[He]2s^22p^5$. How will X's electron affinity compare to its neighbors $O(2p^4)$ and $Ne(2p^6)$?

(A) Equal to Ne (B) Lower than both

(C) Equal to O (D) Much higher than both

34. In light of the diagonal relationship, what trend is expected when comparing the electron affinities of Be and Al (both metals showing low/negative electron affinity)?

(A) Al's electron affinity is close to a halogen's

(B) No relationship

(C) Both show low or negative electron affinity

(D) Be's electron affinity is extremely highly positive

35. Due to lanthanide contraction, what kind of similarity (beyond just radius) is seen in the chemical properties of the 4d and 5d row elements, which isn't seen in 3d/4d pairs?

(A) 4d/5d row elements behave as completely different groups

(B) No difference

(C) 4d and 5d row elements show nearly identical properties, making separation difficult

(D) 4d/5d pairs have less similarity in properties

36. What is the correct descending order of radii for the ions $P^{3-}, S^{2-}, Cl^-, K^+, Ca^{2+}$ (all with 18 electrons)?

(A) $Ca^{2+} > K^+ > Cl^- > S^{2-} > P^{3-}$

(B) $Cl^- > P^{3-} > S^{2-} > K^+ > Ca^{2+}$

(C) $P^{3-} > S^{2-} > Cl^- > K^+ > Ca^{2+}$

(D) All equal

37. Is the near-equal atomic radii of Mo ($Z = 42, 4d$) and W ($Z = 74, 5d$) due to lanthanide contraction, just like Zr/Hf?

(A) Yes; the $4f^{14}$ series provides weak screening

(B) This is a coincidence

(C) No, this occurs for a completely different reason

(D) Mo/W 's radii are actually not equal

38. Compare the hydrated radius and aqueous conductivity of Ca^{2+} and Sr^{2+}.

(A) Both have equal conductivity

(B) Sr^{2+}'s hydrated radius is larger

(C) Ca^{2+}'s conductivity is higher

(D) Ca^{2+}'s conductivity is lower

39. Just like the diagonal relationship between Li and Mg, a diagonal relationship also exists between Be and Al. As a result, what common property do their oxides (BeO and Al_2O_3) show?

(A) Both are amphoteric oxides

(B) Both are strongly basic

(C) Both are strongly acidic

(D) Both are neutral

40. Prove, with reasoning, whether the graphical anomaly in the covalent radius of the period-4 (K → Kr) noble gas Kr occurs for the same reason as for Ne, Ar.

(A) Yes, the same reason

(B) Kr has no radius

(C) Kr's radius is smaller than Br's

(D) No

41. In an octahedral complex, how might the ionic radius of a d^4 (high-spin) cation compare to d^3 and d^5?

(A) May be slightly larger (electron in e_g)

(B) Equal to d^3

(C) Always smaller

(D) No difference

42. What is the correct descending order of ionic radii for $Ti^{2+}, Ti^{3+}, Ti^{4+}$, and what effect does Ti^{4+}'s special feature (no d electrons) have?

(A) Ti^{3+} is the largest (B) All equal

(C) $Ti^{2+} > Ti^{3+} > Ti^{4+}$ (D) $Ti^{4+} > Ti^{3+} > Ti^{2+}$

43. Between the ionic radii of V^{2+} ($3d^3$) and Cr^{2+} ($3d^4$), which one might deviate more from the expected smooth trend?

(A) Both deviate equally

(B) Neither deviates

(C) Cr^{2+} (d^4); an electron entering e_g causes more repulsion

(D) V^{2+} is perfectly symmetric, no deviation

44. Using the definitional differences between atomic, covalent, and ionic radii, explain why the difference between the metallic radius and the ionic (cation) radius of the same element will be most pronounced in a high-charge ion.

(A) The radius contracts the most at high charge

(B) No relationship

(C) Metallic and ionic radii are always equal

(D) The higher the charge, the smaller the difference

45. Between SnO_2 and GeO_2, which one will show more basic character, even though both are +4 oxides of the same Group 14?

(A) Both are equal

(B) GeO_2 is more basic

(C) Both are completely acidic

(D) SnO_2 is more basic

46. What principle does the change in acid-base nature follow across the d-block element Cr's different oxidation-state oxides (CrO, Cr_2O_3, CrO_3)?

(A) Increasing oxidation state changes it from basic to acidic

(B) It always remains basic

(C) No relationship with oxidation number

(D) It always remains acidic

47. An element's electron affinity, despite being the first member of its group, is lower than expected, and the element belongs to period-2, Group 14. What is the explanation?

(A) It's Si; no exception

(B) It's a metal

(C) It's C; its affinity is slightly lower than Si's

(D) No exception occurs in Group 14

48. Which of the following oxide pairs is classified as "amphoteric" but formed from elements of different groups?

(A) Cl_2O_7 and Mn_2O_7

(B) ZnO and Al_2O_3

(C) CO_2 and SO_3

(D) Na_2O and MgO

49. Compare the acidity of HNO_3, HNO_2 (nitrogen's oxidation states +5, +3 respectively), and explain how this comparison is analogous to $HClO_4/HClO_3$.

(A) $HNO_3 > HNO_2$

(B) $HNO_2 > HNO_3$

(C) Equal

(D) Unrelated

50. Between H_2CO_3 and H_2SiO_3 (both with central-atom oxidation number +4), which is the stronger acid, and how does this reasoning align with the S/Se or Cl/I reasoning?

(A) H_2CO_3 is stronger

(B) Equally strong

(C) H_2SiO_3 is stronger

(D) Not comparable