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p-Block Elements — JEE (Main) Pattern Topic Test

FREE SAMPLE TEST · CHEMISTRY · PATTERN OF JEE (MAIN)

DURATION	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
60 minutes	100	25 (20 + 5)	

GENERAL INSTRUCTIONS

1. This question paper has two sections, A and B. All 25 questions are compulsory.
2. Section A has TWENTY (20) multiple-choice questions. Each has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Section B has FIVE (05) questions whose answer is a numerical value. Enter the value rounded off to the nearest integer.
4. Marking scheme for both sections: +4 for a correct answer, −1 for an incorrect answer, 0 if the question is not attempted.
5. Use of a calculator, log tables or any other aid is not allowed.
6. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 60 minutes before you look at them.

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Topics covered: Electronic configuration and trends · Unique behaviour of the first element · Group 13 elements · Group 14 elements · Group 15 elements · Group 16 elements · Group 17 elements · Group 18 elements

SECTION A (Q1–20) · Multiple choice · +4 / 0 / −1

Each question has FOUR options. ONLY ONE of them is correct.

1. Which p-block element of the fifth period has three unpaired electrons in its ground state?

(1) In

(2) Sn

(3) Te

(4) Sb

2. The correct order of the first ionisation enthalpies of the group 13 elements is

(1) B > Al > Ga > In > Tl

(2) B > Tl > Ga > Al > In

(3) B > Ga > Al > Tl > In

(4) B > Tl > Al > Ga > In

3. In aqueous solution, the strongest oxidising agent among the following ions is

(1) Al^{3+}

(2) Ga^{3+}

(3) Tl^{3+}

(4) In^{3+}

4. Which of the following statements about boron is NOT correct?

(1) The maximum covalency of boron is four.

(2) Boron forms only covalent compounds, unlike aluminium which also forms ionic ones.

(3) With excess fluoride ion, BF_3 forms the octahedral ion $[BF_6]^{3-}$, as AlF_3 forms $[AlF_6]^{3-}$.

(4) Boron has a much higher first ionisation enthalpy than the other members of its group.

5. The correct order of Lewis acid strength of the boron trihalides is

(1) $BF_3 < BCl_3 < BBr_3 < BI_3$

(2) $BI_3 < BBr_3 < BCl_3 < BF_3$

(3) $BCl_3 < BF_3 < BBr_3 < BI_3$

(4) $BF_3 < BBr_3 < BCl_3 < BI_3$

6. The tendency of the group 14 elements to show catenation decreases in the order

(1) C > Ge > Si > Sn

(2) Si > C > Ge > Sn

(3) C > Si > Sn > Ge

(4) C > Si > Ge > Sn

7. Statement I: $SnCl_2$ is a reducing agent.
Statement II: PbO_2 is an oxidising agent.
In the light of the above statements, choose the correct answer from the options given below:

(1) Both Statement I and Statement II are true

(2) Statement I is true but Statement II is false

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are false

8. Assertion A: Carbon dioxide is a gas made of discrete molecules, whereas silicon dioxide is a hard, high-melting network solid.
Reason R: Carbon forms strong pπ–pπ double bonds with oxygen, whereas silicon, being larger, does not and forms four Si–O single bonds instead.
In the light of the above statements, choose the correct answer from the options given below:

(1) Both A and R are true and R is the correct explanation of A

(2) Both A and R are true but R is NOT the correct explanation of A

(3) A is true but R is false

(4) A is false but R is true

9. Which of the following orders is correct for the hydrides of group 15?

(1) Basic strength: $NH_3 < PH_3 < AsH_3 < SbH_3$

(2) Reducing character: $NH_3 > PH_3 > AsH_3 > SbH_3$

(3) Thermal stability: $NH_3 > PH_3 > AsH_3 > SbH_3$

(4) Boiling point: $NH_3 > SbH_3 > AsH_3 > PH_3$

10. The correct order of the boiling points of the group 15 hydrides is

(1) $NH_3 < PH_3 < AsH_3 < SbH_3$

(2) $PH_3 < AsH_3 < NH_3 < SbH_3$

(3) $PH_3 < NH_3 < AsH_3 < SbH_3$

(4) $SbH_3 < AsH_3 < PH_3 < NH_3$

11. Use the bond enthalpies (kJ/mol): N≡N 946, N–N 163, P≡P 490, P–P 201. The enthalpy changes for $2N_2(g) \rightarrow N_4(g)$ and $2P_2(g) \rightarrow P_4(g)$, where N_4 and P_4 are tetrahedral molecules with six single bonds, are, respectively,

(1) −914 and +226 kJ/mol

(2) +914 and +226 kJ/mol

(3) +1892 and −1206 kJ/mol

(4) +914 and −226 kJ/mol

12. Which of the following orders of a property of the group 16 hydrides is correct?

(1) Thermal stability: $H_2O < H_2S < H_2Se < H_2Te$

(2) Acid strength: $H_2O < H_2S < H_2Se < H_2Te$

(3) Boiling point: $H_2O < H_2S < H_2Se < H_2Te$

(4) Bond angle: $H_2O < H_2S < H_2Se < H_2Te$

13. The group 16 element with the most negative electron gain enthalpy is

(1) O

(2) Se

(3) Te

(4) S

14. The correct order of the bond dissociation enthalpies of the halogens is

(1) $F_2 > Cl_2 > Br_2 > I_2$

(2) $Cl_2 > F_2 > Br_2 > I_2$

(3) $Cl_2 > Br_2 > F_2 > I_2$

(4) $I_2 > Br_2 > Cl_2 > F_2$

15. Use the data (kJ/mol): bond dissociation enthalpy F_2 158.8, Cl_2 242.6; electron gain enthalpy F −333, Cl −349; hydration enthalpy F^- −515, Cl^- −381. The enthalpy changes for $\frac{1}{2}X_2(g) \rightarrow X^-(aq)$ for X = F and X = Cl are about, respectively,

(1) −769 and −609 kJ/mol

(2) −689 and −487 kJ/mol

(3) −609 and −769 kJ/mol

(4) −254 and −228 kJ/mol

16. Which of the following reactions does NOT take place in aqueous solution under standard conditions?

(1) $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$

(2) $F_2 + 2Cl^- \rightarrow 2F^- + Cl_2$

(3) $Br_2 + 2I^- \rightarrow 2Br^- + I_2$

(4) $I_2 + 2Br^- \rightarrow 2I^- + Br_2$

17. Fluorine shows only the −1 oxidation state in its compounds, whereas chlorine, bromine and iodine also show +1, +3, +5 and +7. The best reason is that fluorine

(1) has the least negative electron gain enthalpy of the halogens

(2) is the most electronegative element and has no d orbitals in its valence shell

(3) has the lowest bond dissociation enthalpy of the halogens

(4) forms the strongest hydrogen bonds

18. Bartlett's preparation of the first noble gas compound began from the observation that the first ionisation enthalpy of the O_2 molecule (1175 kJ/mol) is almost the same as that of

(1) Ar

(2) Kr

(3) Xe

(4) Rn

19. Statement I: The boiling points of the noble gases increase from helium to radon.
Statement II: The first ionisation enthalpies of the noble gases increase from helium to radon.
In the light of the above statements, choose the correct answer from the options given below:

(1) Both Statement I and Statement II are true

(2) Statement I is true but Statement II is false

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are false

20. Statement I: Like phosphorus, nitrogen forms a pentachloride, NCl_5.
Statement II: Down group 15 the stability of the +5 oxidation state decreases and that of the +3 state increases.
In the light of the above statements, choose the correct answer from the options given below:

(1) Both Statement I and Statement II are true

(2) Statement I is true but Statement II is false

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are false

SECTION B (Q21–25) · Numerical value · +4 / 0 / −1

The answer to each question is a NUMERICAL VALUE. Enter it rounded off to the nearest integer.

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21. The number of the following elements whose atoms have exactly two unpaired electrons in the ground state is _____.
Ga, As, Kr, Bi, Cl, Po, Ge, O, In, Te, Sb, Si

Answer: _____

22. The total number of electrons in the d and f orbitals of a ground-state lead atom (Z = 82) is _____.

Answer: _____

23. Use the bond enthalpies (kJ/mol): H–H 436, F–F 158.8 and H–F 574. The standard enthalpy of formation of HF(g) is −x kJ/mol. The value of x (to the nearest integer) is _____.

Answer: _____

24. The number of the following hydrides in which the H–E–H bond angle is less than 100° is _____.
NH_3, PH_3, AsH_3, SbH_3, H_2O, H_2S, H_2Se, H_2Te

Answer: _____

25. The number of amphoteric oxides among the following is _____.
B_2O_3, Al_2O_3, Ga_2O_3, In_2O_3, GeO_2, SnO_2, PbO_2, N_2O_3, As_2O_3, Sb_2O_3, Bi_2O_3, SO_2

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
(4)	(2)	(3)	(3)	(1)	(4)	(1)	(1)	(3)	(2)

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(4)	(2)	(4)	(3)	(1)	(4)	(2)	(3)	(2)	(3)

Q21	Q22	Q23	Q24	Q25
5	44	277	6	6

WORKED SOLUTIONS

Q1. Answer (4). Period 5 p-block: In $5p^1$ (1 unpaired), Sn $5p^2$ (2), Sb $5p^3$ (3, Hund's rule), Te $5p^4$ (2). So Sb.

Q2. Answer (2). Values (kJ/mol): B 801, Tl 589, Ga 579, Al 577, In 558. The fall from B to Al is the usual one down a group. Ga is slightly above Al because its ten 3d electrons shield poorly; Tl is above In because the fourteen 4f and ten 5d electrons shield even more poorly. So B > Tl > Ga > Al > In.

Q3. Answer (3). $E°(M^{3+}/M)$: Al −1.66, Ga −0.56, In −0.34, Tl +1.26 V. Only Tl^{3+} has a positive value; the inert pair effect makes +1 the stable state of thallium, so Tl^{3+} is readily reduced and is the strongest oxidising agent.

Q4. Answer (3). Boron's valence shell (n = 2) has only one s and three p orbitals, so it can form at most four bonds: with F^- it gives tetrahedral $[BF_4]^-$. Aluminium can use its 3d orbitals and so forms $[AlF_6]^{3-}$. The other three statements are correct (B is small with a high ionisation enthalpy of 801 kJ/mol, so its compounds are covalent).

Q5. Answer (1). Electronegativity alone would make BF_3 the strongest, but in BF_3 the filled 2p orbital of F overlaps well with the empty 2p orbital of B (pπ–pπ back bonding), which partly fills boron's vacancy. The overlap gets poorer as the halogen gets bigger (F 64, Cl 99, Br 114, I 133 pm), so the electron deficiency of boron, and its Lewis acidity, increase: BF_3 < BCl_3 < BBr_3 < BI_3.

Q6. Answer (4). Catenation follows the strength of the element–element bond: C–C 348, Si–Si 297, Ge–Ge 260, Sn–Sn 240 kJ/mol. So C > Si > Ge > Sn (lead shows none).

Q7. Answer (1). For tin the +4 state is the more stable, so Sn^{2+} is easily oxidised to Sn^{4+}: $SnCl_2$ is a reducing agent. For lead the inert pair effect makes +2 the more stable state, so Pb^{4+} in PbO_2 is easily reduced: PbO_2 is an oxidising agent. Both statements are true.

Q8. Answer (1). C is small, so its 2p orbitals overlap well with those of O, giving O=C=O molecules held by weak van der Waals forces. The 3p orbitals of Si overlap poorly in π fashion, so each Si forms four single Si–O bonds to bridging O atoms, giving a three-dimensional network. Both are true and R explains A.

Q9. Answer (3). E–H bond enthalpies fall down the group (N–H 389, P–H 322, As–H 297, Sb–H 255 kJ/mol), so thermal stability falls and reducing character rises: (3) is correct and (2) is reversed. Basic strength falls from NH_3 down the group, so (1) is reversed. Boiling points (K): SbH_3 254.6 > NH_3 238.5 > AsH_3 210.6 > PH_3 185.5, so (4) is wrong.

Q10. Answer (2). From PH_3 to SbH_3 the boiling point rises with molar mass (185.5, 210.6, 254.6 K). NH_3 is raised to 238.5 K by hydrogen bonding, which puts it above AsH_3 but still below the much heavier SbH_3. So PH_3 < AsH_3 < NH_3 < SbH_3.

Q11. Answer (4). ΔH = bonds broken − bonds formed. For N: 2 × 946 − 6 × 163 = 1892 − 978 = +914 kJ/mol. For P: 2 × 490 − 6 × 201 = 980 − 1206 = −226 kJ/mol. Small N forms strong pπ–pπ triple bonds, so nitrogen stays as N_2; for phosphorus single bonds win and it exists as P_4.

Q12. Answer (2). E–H bond enthalpy falls from O–H (463) to Te–H (238 kJ/mol), so H_2Te gives up H^+ most easily: acid strength rises down the group (pKa 15.7, 7.0, 3.8, 2.6), and (2) is correct. Thermal stability falls, so (1) is reversed. H_2O boils highest (373 K, hydrogen bonding), so (3) is wrong. Bond angles fall (104.5°, 92.1°, 91°, 90°), so (4) is reversed.

Q13. Answer (4). Values (kJ/mol): O −141, S −200, Se −195, Te −190. Oxygen is out of line because its small, compact 2p subshell repels an incoming electron strongly, so sulfur has the most negative value.

Q14. Answer (3). Values (kJ/mol): Cl_2 242.6, Br_2 192.8, F_2 158.8, I_2 151.1. F_2 is anomalously weak because the lone pairs on the two small F atoms are close together and repel each other. So $Cl_2 > Br_2 > F_2 > I_2$.

Q15. Answer (1). $\Delta H = \frac{1}{2}\Delta dissH + \Delta egH + \Delta hydH$. F: 79.4 − 333 − 515 = −768.6 ≈ −769 kJ/mol. Cl: 121.3 − 349 − 381 = −608.7 ≈ −609 kJ/mol. The low F–F bond enthalpy and the very large hydration enthalpy of the small F^- ion make F_2 the stronger oxidising agent although Cl has the more negative electron gain enthalpy.

Q16. Answer (4). $E°(X_2/X^-)$: F_2 2.87, Cl_2 1.36, Br_2 1.09, I_2 0.54 V. A halogen oxidises the halide ions below it, so (1), (2), (3) occur. I_2 (0.54 V) cannot oxidise Br^- (1.09 V): reaction (4) has $E°cell = 0.54 - 1.09 = -0.55$ V and does not occur.

Q17. Answer (2). Positive states need a more electronegative partner, and F is the most electronegative element (4.0). Higher states also need unpaired electrons to be promoted to vacant d orbitals, which fluorine (n = 2) does not have. Option (1) is false (that is iodine) and (3), (4) are true facts that do not explain it.

Q18. Answer (3). First ionisation enthalpies (kJ/mol): Ar 1520, Kr 1351, Xe 1170, Rn 1037. Xe (1170) is closest to O_2 (1175); since O_2 reacts with PtF_6 to give $O_2^+[PtF_6]^-$, Bartlett made $Xe^+[PtF_6]^-$.

Q19. Answer (2). Boiling points (K): He 4.2, Ne 27.1, Ar 87.2, Kr 119.7, Xe 165, Rn 211: they rise as the atoms get bigger and more polarisable, so I is true. Ionisation enthalpies fall down the group (2372 to 1037 kJ/mol), so II is false.

Q20. Answer (3). Nitrogen's valence shell (n = 2) has no d orbitals, so its covalency cannot exceed four and NCl_5 does not exist, while P (n = 3) forms PCl_5: Statement I is false. The inert pair effect makes the ns^2 pair less available down the group, so +5 becomes less stable and +3 more stable (Bi(V) is a strong oxidising agent): Statement II is true.

Q21. Answer 5. Two unpaired electrons means np^2 or np^4: Ge ($4p^2$), Si ($3p^2$), O ($2p^4$), Te ($5p^4$), Po ($6p^4$). Ga, In (p^1) and Cl (p^5) have one; As, Sb, Bi (p^3) have three; Kr has none. Answer 5.

Q22. Answer 44. Pb: [Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^2$. d electrons: $3d^{10} + 4d^{10} + 5d^{10} = 30$; f electrons: $4f^{14} = 14$. Total 44.

Q23. Answer 277. $\frac{1}{2}H_2 + \frac{1}{2}F_2 \rightarrow HF$: $\Delta fH = \frac{1}{2}(436) + \frac{1}{2}(158.8) - 574 = 218 + 79.4 - 574 = -276.6$ kJ/mol. So x = 277.

Q24. Answer 6. NH_3 107.8° and H_2O 104.5° are near the tetrahedral angle. In the heavier hydrides the larger central atom uses almost pure p orbitals for bonding, so the angles are close to 90°: PH_3 93.6°, AsH_3 91.8°, SbH_3 91.3°, H_2S 92.1°, H_2Se 91°, H_2Te 90°. Answer 6.

Q25. Answer 6. Down each group, oxides go from acidic to amphoteric to basic as metallic character rises. Group 13: B_2O_3 acidic, Al_2O_3 and Ga_2O_3 amphoteric, In_2O_3 basic. Group 14: GeO_2 acidic, SnO_2 and PbO_2 amphoteric. Group 15: N_2O_3 acidic, As_2O_3 and Sb_2O_3 amphoteric, Bi_2O_3 basic. SO_2 is acidic. Amphoteric: 6.

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: configurations and unpaired electrons from the Aufbau rules, covalency limits by counting valence-shell orbitals, enthalpy cycles by adding up the data, and trends against tables of measured ionisation enthalpies, bond enthalpies, boiling points, bond angles, pKa values and electrode potentials typed in separately from the questions.