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Classification of Elements and Periodicity in Properties — 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: Modern periodic law · Modern periodic table · Nomenclature of elements with Z > 100 · Electronic configuration and position · Atomic and ionic radii · Ionisation enthalpy · Electron gain enthalpy · Electronegativity · Valence and oxidation states · Chemical reactivity

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

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

1. The correct order of the first ionisation enthalpies of the elements B, C, N and O is

(1) B < C < N < O

(2) C < B < O < N

(3) B < C < O < N

(4) B < O < C < N

2. The correct order of the electron gain enthalpies (most negative first) of the halogens is

(1) F > Cl > Br > I

(2) Cl > F > Br > I

(3) Cl > Br > F > I

(4) I > Br > Cl > F

3. Which of the following isoelectronic species has the largest radius?

(1) F^-

(2) Na^+

(3) O^{2-}

(4) N^{3-}

4. Assertion A: The atomic radius of gallium is less than that of aluminium.
Reason R: The ten 3d electrons of gallium shield the nuclear charge poorly, so its outer electrons feel a larger effective nuclear charge.
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) A is true but R is false

(3) A is false but R is true

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

5. The element with atomic number 34 is placed in the periodic table in

(1) period 4, group 16, p-block

(2) period 4, group 6, d-block

(3) period 3, group 16, p-block

(4) period 4, group 14, p-block

6. The element with atomic number 114 (flerovium) belongs to

(1) period 7, group 16

(2) period 6, group 14

(3) period 7, group 14

(4) period 4, group 4

7. Which of the following elements has the highest second ionisation enthalpy?

(1) Mg

(2) Al

(3) Na

(4) Si

8. Down group 15, the +5 oxidation state becomes less stable and the +3 state more stable. The element in which the +5 state is least stable is

(1) Bi

(2) P

(3) N

(4) Sb

9. Which of the following oxides is amphoteric?

(1) MgO

(2) Al_2O_3

(3) P_4O_{10}

(4) SiO_2

10. The correct order of the Pauling electronegativities of F, O, N and Cl is

(1) F > O > Cl > N

(2) F > Cl > O > N

(3) O > F > Cl > N

(4) F > O > N > Cl

11. Which of the following ions has the smallest radius?

(1) Li^+

(2) Mg^{2+}

(3) Al^{3+}

(4) Na^+

12. Which of the following has a positive electron gain enthalpy (energy must be supplied to add an electron)?

(1) O

(2) Cl

(3) S

(4) Ne

13. Statement I: According to the modern periodic law, the properties of the elements are periodic functions of their atomic numbers.
Statement II: The sixth period of the periodic table contains 32 elements.
In the light of the above statements, choose the correct answer from the options given below:

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

(2) Both Statement I and Statement II are true

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

(4) Both Statement I and Statement II are false

14. The IUPAC temporary name of the element with atomic number 120 is

(1) unbinilium

(2) unnilbium

(3) binilunium

(4) ununbium

15. The first ionisation enthalpy of sodium is 496 kJ/mol. The enthalpy change for $Na^+(g) + e^- \rightarrow Na(g)$ is

(1) +496 kJ/mol

(2) −53 kJ/mol

(3) −496 kJ/mol

(4) +4562 kJ/mol

16. The atomic number of the element of the fourth period that has three unpaired electrons in its p subshell is

(1) 15

(2) 23

(3) 33

(4) 51

17. Consider the following statements.

(A) In aqueous solution, lithium is the strongest reducing agent among the alkali metals.

(B) The oxidising power of the halogens decreases in the order $F_2 > Cl_2 > Br_2 > I_2$.

(C) The first ionisation enthalpy generally decreases down a group.

(D) Metallic character increases from left to right across a period.

(E) Chlorine is more electronegative than fluorine.

Choose the correct answer from the options given below:

(1) (B), (C) and (D) only

(2) (A), (C) and (E) only

(3) (A), (B) and (C) only

(4) (A), (B), (C) and (D) only

18. The first four ionisation enthalpies of an element are 738, 1451, 7733 and 10 540 kJ/mol. The element belongs to group

(1) 1

(2) 13

(3) 14

(4) 2

19. Which pair of elements has almost the same atomic radius?

(1) Zr and Hf

(2) Ti and Zr

(3) Sc and Y

(4) Cu and Ag

20. The first and second electron gain enthalpies of oxygen are −141 and +780 kJ/mol. The enthalpy change for $O(g) + 2e^- \rightarrow O^{2-}(g)$ is

(1) −921 kJ/mol

(2) +639 kJ/mol

(3) −141 kJ/mol

(4) +780 kJ/mol

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.

21. The number of elements among the following whose first ionisation enthalpy is greater than that of oxygen is _____.

Li, Be, B, C, N, F, Ne, Na, P, S, Cl, Ar

Answer: _____

22. The atomic number of the element in period 5 and group 17 of the periodic table is _____.

Answer: _____

23. Gold has atomic number 79. The number of the group of the periodic table in which it is placed is _____.

Answer: _____

24. The first and second ionisation enthalpies of magnesium are 738 and 1451 kJ/mol. The energy (in kJ) needed to convert 1 mol of gaseous Mg atoms into gaseous Mg^{2+} ions is _____.

Answer: _____

25. The number of species among the following that are isoelectronic with neon is _____.

N^{3-}, O^{2-}, F^-, Na^+, Mg^{2+}, Al^{3+}, K^+, Ca^{2+}, S^{2-}, Cl^-

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

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

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

Q21	Q22	Q23	Q24	Q25
4	53	11	2189	6

WORKED SOLUTIONS

Q1. Answer (3). Ionisation enthalpy generally rises across a period, with two breaks: O ($2p^4$) is below N because N has a stable half-filled $2p^3$ set and in O one 2p electron is paired, so repulsion helps remove it. (Values: B 801, C 1086, O 1314, N 1402 kJ/mol.)

Q2. Answer (2). Cl has the most negative value (−349 kJ/mol). F (−328) is less negative than expected because the incoming electron enters the small, crowded 2p shell and is repelled by the electrons already there. Then Br (−325) and I (−295).

Q3. Answer (4). All have 10 electrons. The fewer the protons, the weaker the pull on them: N^{3-} (Z = 7) is the largest, then O^{2-} (8), F^- (9) and Na^+ (11).

Q4. Answer (1). Ga (135 pm) is smaller than Al (143 pm) although it lies below it. Ga has the filled $3d^{10}$ set, whose poor shielding raises the effective nuclear charge on the 4s and 4p electrons. Both are true and R explains A.

Q5. Answer (1). Z = 34: $[Ar]3d^{10}4s^24p^4$. The highest n is 4 (period 4); the last electron enters a p orbital (p-block); group = 10 + 2 + 4 = 16. It is selenium.

Q6. Answer (3). After Rn (86), period 7 fills $7s^2$, $5f^{14}$, $6d^{10}$ and then 7p. Z = 114 = 86 + 2 + 14 + 10 + 2: configuration $[Rn]5f^{14}6d^{10}7s^27p^2$, so period 7, group 14 (below lead).

Q7. Answer (3). Na^+ has the neon configuration; its second electron must come from the compact 2p shell, close to the nucleus: 4562 kJ/mol. For Mg, Al and Si the second electron still comes from the n = 3 shell (1451, 1817, 1577 kJ/mol).

Q8. Answer (1). The inert pair effect: the ns^2 electrons of the heavy elements are held more tightly (poor shielding by d and f electrons), so they take part in bonding less readily. Bi is the heaviest of the four, and Bi(V) compounds such as $NaBiO_3$ are strong oxidising agents.

Q9. Answer (2). Across period 3 oxides change from basic to acidic: Na_2O, MgO basic; Al_2O_3 amphoteric (dissolves in both HCl and NaOH); SiO_2, P_4O_{10}, SO_3, Cl_2O_7 acidic.

Q10. Answer (1). Pauling values: F 3.98, O 3.44, Cl 3.16, N 3.04. Chlorine is more electronegative than nitrogen even though N is in period 2.

Q11. Answer (3). Na^+, Mg^{2+} and Al^{3+} are isoelectronic (10 electrons): the radius falls as the nuclear charge rises, so Al^{3+} (53.5 pm) is smallest. Li^+ (76 pm) is a little larger than Mg^{2+} (72 pm), the diagonal relationship.

Q12. Answer (4). Neon has a closed shell, so an added electron must go into the next, 3s, shell far from the nucleus: $\Delta_{eg}H \approx +116$ kJ/mol. O (−141), S (−200) and Cl (−349) release energy.

Q13. Answer (2). Statement I is Moseley's form of the periodic law (Mendeleev used atomic masses). Period 6 fills 6s, 4f, 5d and 6p: 2 + 14 + 10 + 6 = 32 elements (Cs to Rn). Both are true.

Q14. Answer (1). Digits 1, 2, 0 are un, bi, nil, followed by -ium: unbinilium (symbol Ubn).

Q15. Answer (3). This is the reverse of the first ionisation, so $\Delta H = -496$ kJ/mol. (-53 kJ/mol is the electron gain enthalpy of the neutral atom, $Na(g) + e^- \rightarrow Na^-(g)$.)

Q16. Answer (3). Three unpaired p electrons means np^3 (group 15). In period 4 that is arsenic, $[Ar]3d^{10}4s^24p^3$, Z = 33. (P, 15, is in period 3 and Sb, 51, in period 5; V, 23, has three unpaired d electrons.)

Q17. Answer (3). (A) $E°(Li^+/Li) = -3.04$ V is the most negative, because the small Li^+ ion has a very large hydration enthalpy. (B) E° falls from 2.87 V (F_2) to 0.54 V (I_2). (C) True: outer electrons are farther from the nucleus. (D) False: metallic character decreases across a period. (E) False: F (3.98) > Cl (3.16).

Q18. Answer (4). The big jump is between the second (1451) and third (7733) values: two electrons are easily removed and the third comes from a noble-gas core. Two valence electrons: group 2 (these are the values for Mg).

Q19. Answer (1). Hf comes after the fourteen lanthanoids, whose 4f electrons shield poorly; the steady contraction across them (lanthanoid contraction) cancels the expected increase in size from Zr to Hf: 160 and 159 pm. The other pairs differ by 13 to 18 pm.

Q20. Answer (2). Adding the second electron to the negative O^- ion needs energy to overcome the repulsion. Overall: $-141 + 780 = +639$ kJ/mol. The O^{2-} ion is stable in solids only because of the large lattice enthalpy it brings.

Q21. Answer 4. $IE_1(O) = 1314$ kJ/mol. Higher: N (1402), F (1681), Ne (2081), Ar (1521). Cl (1251), P (1012), C (1086), S (1000) and the rest are lower. Four.

Q22. Answer 53. Period 5 runs from Rb (37) to Xe (54); group 17 is the element just before the noble gas: 53 (iodine, $[Kr]4d^{10}5s^25p^5$).

Q23. Answer 11. Au: $[Xe]4f^{14}5d^{10}6s^1$. For a d-block element the group number is the number of $(n-1)d + ns$ electrons: $10 + 1 = 11$ (with Cu and Ag).

Q24. Answer 2189. $Mg(g) \rightarrow Mg^+(g) \rightarrow Mg^{2+}(g)$: $738 + 1451 = 2189$ kJ.

Q25. Answer 6. Neon has 10 electrons: N^{3-} (7 + 3), O^{2-}, F^-, Na^+ (11 − 1), Mg^{2+} and Al^{3+} have 10. K^+, Ca^{2+}, S^{2-} and Cl^- have 18 (argon). Six.

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: positions in the periodic table were derived from Aufbau configurations, period lengths by counting the subshells each period fills, and trends against tables of measured ionisation enthalpies, electron gain enthalpies, electronegativities, radii and electrode potentials typed in separately from the questions.