WC

WEIRD CHEMIST

Group 18 Elements — The Noble Gases

SOLUTIONS • Chapter: p-Block Elements

DPP-11 SOL

Chapter: p-Block: Group 18 (Noble Gases) **Total Qs:** 35 **Format:** Four-Box Detailed
Level: JEE / NEET

TOPIC 1 Introduction

(a)–(c) Elements, Nature & Occurrence

Master Formulae & Key Concepts

- Alpha decay: ${}^{A}_{Z}\text{X} \rightarrow {}^{A-4}_{Z-2}\text{Y} + {}^{4}_{2}\text{He}$ — mass number drops by 4, atomic number drops by 2.
- Radon's only source: ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$ (no atmospheric source for Rn).
- Abundance in dry air: Ar is the **major** noble-gas constituent ($\sim$1% by volume); all others are trace.
- Commercial He source = natural gas, **NOT** the atmosphere.

SKILL: Analytical Ability

Q1 **Correct Option: (3)**

[A] Conceptual Approach (Hinglish)

Nuclear equation mein hamesha do cheezein check karo — mass number (upar wala) aur atomic number (neeche wala) — dono sides pe balance hone chahiye. Yahan Ra se Rn banate waqt ek chhota particle nikal raha hai jiska mass 4 aur charge +2 hai — yeh identity hi alpha particle (${}^{4}_{2}\text{He}$) ki hoti hai, kisi aur decay ki nahi.

[S] Step-by-Step

- Reactant: ${}^{226}_{88}\text{Ra}$ Products: ${}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$
- Mass number check: $226 = 222 + 4$ ✓
- Atomic number check: $88 = 86 + 2$ ✓
- The emitted particle ${}^{4}_{2}\text{He}$ (2 protons + 2 neutrons) is, by definition, an alpha particle.

[Ans] Final Answer

Option (3) — Alpha decay; both mass number ($226 = 222 + 4$) and atomic number ($88 = 86 + 2$) balance perfectly, confirming emission of one α-particle.

[!] Common Mistake

Students confuse beta decay (atomic number up by 1, mass number unchanged, electron emitted) with this case. Always check the specific particle written on the product side before naming the decay type.

SKILL: Conceptual Clarity

Q2 — Correct Option: (4)

[A] Conceptual Approach (Hinglish)

Naam 'noble' isliye mila kyunki jaise noble metals (Au, Pt) chemically bahut inert hote hain, waise hi yeh Group 18 gases bhi kisi se easily react nahi karte — 'noble' ka matlab hai 'reactive nahi, apni marzi ka'.

[S] Step-by-Step

- Noble metals (gold, platinum) resist corrosion/chemical attack — source of the analogy.
- Group 18 elements have completely filled valence shells (ns^2np^6, except He: $1s^2$).
- High ionisation enthalpy + large positive electron gain enthalpy $\Rightarrow$ little tendency to lose/gain electrons.
- Result: very few compounds form, so they are called "noble" by analogy with noble metals.

[Ans] Final Answer

Option (4) — named "noble" by analogy with noble metals, because they are chemically unreactive and form very few compounds.

[!] Common Mistake

Don't confuse this with mineral-occurrence facts — the "noble" naming is purely an inertness analogy, not about where the gases are found.

SKILL: Application Skills

Q3 — Correct Option: (2)

[A] Conceptual Approach (Hinglish)

Jab bhi koi radioactive element alpha decay karta hai, wahan se ${}^{4}_{2}He$ nucleus nikalta hai. Yeh nucleus electron pakad ke neutral He atom ban jaata hai aur mineral ke andar hi phas (trap) jaata hai — bilkul waise hi jaise Ra se Rn bante waqt dekha tha.

[S] Step-by-Step

- Pitchblende, monazite, cleveite contain radioactive elements (U, Th, Ra series).
- These undergo repeated alpha decay: emits ${}_{2}^{4}$He nuclei (same process as Q1).
- The He^{2+} nuclei gain 2 electrons from surroundings $\rightarrow$ neutral He atoms.
- Trapped inside the solid crystal lattice, helium accumulates over geological time.

[Ans] Final Answer

Option (2) — Helium accumulates via alpha decay of radioactive elements in the mineral; the emitted ${}_{2}^{4}$He nuclei become trapped He atoms after gaining electrons.

[!] Common Mistake

Don't assume helium is "injected" from outside (volcanic activity) — the source is internal, generated in-situ by radioactive decay.

SKILL: Diagram-Based Visual Literacy

Q4 Correct Option: (1)

[A] Conceptual Approach (Hinglish)

Table mein clearly likha hai — Argon hi hai jo dry air mein noble gases ka 'major constituent' hai ($\sim$1% volume). Helium ka main commercial source atmosphere nahi, natural gas hai — yeh dono facts directly table se match karte hain.

[S] Step-by-Step

- Table: Ar is explicitly marked "Major constituent" of atmospheric noble gases.
- He's row shows source = "Natural gas; radioactive minerals" — not primarily atmosphere.
- Cross-check: He is not the most abundant noble gas in air (Ar is); Rn is not found in natural gas (source is Ra-decay only); all six gases are NOT in equal proportion.

[Ans] Final Answer

Option (1) — Argon is the dominant noble gas in dry air; helium's main commercial source is natural gas, not the atmosphere.

[!] Common Mistake

Don't assume "lightest element" (He) means "most abundant in air" — abundance depends on actual atmospheric data, not atomic mass.

SKILL: Time Management and Strategic Thinking

Q5 Correct Option: (3)

[A] Conceptual Approach (Hinglish)

Yeh 'assertion combination' question hai — har statement ko table se individually verify karo. Statement II mein 'minor' likha hai jabki table mein Argon 'Major constituent' bola gaya hai — yehi ek statement galat hai, baaki teeno sahi hain.

[S] Step-by-Step

- I: True — only Rn has "No atmospheric source"; all others do occur in air.
- II: False — table labels Ar as the "Major constituent," not minor.
- III: True — He's primary source listed is natural gas.
- IV: True — table marks Xe as "Rarest (with Rn)".

[Ans] Final Answer

Option (3) — I, III and IV only are correct; statement II is false since argon is the major (not minor) noble-gas constituent of air.

[!] Common Mistake

Always re-read the exact adjective used ("major" vs "minor") against the table before marking a statement true or false.

TOPIC 2 Atomic Properties

(a)–(e) Electronic Configuration, Atomic Radii, Ionisation Enthalpy, Electron Gain Enthalpy & Electronegativity

Master Formulae & Key Concepts

- Configuration: He $= 1s^2$; others $= ns^2np^6$ ($n = 2$ to 6).
- Atomic radii (pm): He 120 $<$ Ne 160 $<$ Ar 190 $<$ Kr 200 $<$ Xe 220 — increases down the group, but increments are uneven.
- IE_1 (kJ mol^{-1}): He 2372 (highest of any element) $>$ Ne 2080 $>$ Ar 1520 $>$ Kr 1351 — decreases down the group.
- Electron gain enthalpy: always positive (unfavourable); Ne $(+116)$ is even higher than He $(+48)$.
- Zero inter-shell shielding in He's $1s^2 \Rightarrow$ abnormally high IE_1.

SKILL: Analytical Ability

Q6 Correct Option: (4)

[A] Conceptual Approach (Hinglish)

He ke sirf 2 electron hain aur woh dono 1s orbital mein hain — inke beech koi 'inner shell' nahi hai jo shielding de sake. Isliye nucleus ka pura $+2$ charge dono electrons pe seedha lagta hai, aur unhe nikalna sabse mushkil ho jaata hai.

[S] Step-by-Step

- He config: $1s^2$ — only one shell, zero inner-shell (core) shielding.
- Effective nuclear charge felt by each 1s electron is very close to full nuclear charge $(+2)$.
- Removing an electron breaks a completely filled, maximally stable shell.
- High Z_{eff} + filled-shell stability $\Rightarrow$ $\text{IE}_1 = 2372$ kJ mol^{-1}, highest of all known elements.

[Ans] Final Answer

Option (4) — Zero inter-shell shielding in the $1s^2$ configuration gives helium the highest effective nuclear charge per electron and hence the highest ionisation enthalpy of any element.

[!] Common Mistake

Don't reason from atomic mass ("heaviest per electron") — IE trends are governed by effective nuclear charge and shell structure, not mass.

SKILL: Conceptual Clarity

Q7 Correct Option: (2)

[A] Conceptual Approach (Hinglish)

n=1 shell mein sirf 's' subshell hota hai, 'p' hota hi nahi — isliye He ka valence shell $1s^2$ pe hi completely fill ho jaata hai. Baaki sab ke liye valence shell ns^2np^6 pe fill hota hai — dono cases mein 'completely filled outer shell' wahi common wajah hai stability ki.

[S] Step-by-Step

- Shell $n = 1$ allows only the $1s$ subshell ($l = 0$ only) — maximum capacity is 2 electrons, i.e. $1s^2$.
- For $n \geq 2$ (Ne, Ar, Kr, Xe, Rn), valence shell has both s and p subshells, filling as ns^2np^6 (octet).
- Both $1s^2$ and ns^2np^6 represent the maximum possible occupancy of their respective valence shells.

[Ans] Final Answer

Option (2) — Helium's $1s^2$ is an exception only because the first shell lacks a p-subshell; it is equally as stable as ns^2np^6 because both represent a completely filled valence shell.

[!] Common Mistake

Do not write He's configuration as "$1s^2 2s^0$" — this is incorrect and unnecessary; $1s^2$ alone is the correct, complete ground-state configuration.

SKILL: Application Skills

Q8 — Correct Option: (1)

[A] Conceptual Approach (Hinglish)

Bas consecutive pairs ke differences nikaalo: He$\rightarrow$Ne$=$ 40, Ne$\rightarrow$Ar$=$ 30, Ar$\rightarrow$Kr$=$ 10, Kr$\rightarrow$Xe$=$ 20. Sabse chhota jump Ar se Kr ke beech hai — sirf 10 pm.

[S] Step-by-Step

- He (120) $\rightarrow$ Ne (160): $\Delta = 40$ pm
- Ne (160) $\rightarrow$ Ar (190): $\Delta = 30$ pm
- Ar (190) $\rightarrow$ Kr (200): $\Delta = 10$ pm $\leftarrow$ smallest
- Kr (200) $\rightarrow$ Xe (220): $\Delta = 20$ pm

[Ans] Final Answer

Option (1) — Ar to Kr shows the smallest increase in atomic radius (only 10 pm).

[!] Common Mistake

Don't just compare final radii sizes — the question asks for the smallest *increase* (difference), not the smallest absolute radius.

SKILL: Diagram-Based Visual Literacy

Q9 — Correct Option: (3)

[A] Conceptual Approach (Hinglish)

IE ka trend seedha hai — He se Kr tak ghatta hi jaata hai (size badhne ke saath expected). EGE sab positive hain (koi bhi noble gas khushi khushi electron nahi leta), aur Ne ka EGE (116) sabse zyada hai — He (48) se bhi zyada, yeh table se confirm hota hai.

[S] Step-by-Step

- IE trend: He (2372) $>$ Ne (2080) $>$ Ar (1520) $>$ Kr (1351) — steadily decreasing.
- EGE values: He $= +48$, Ne $= +116$, Ar $= +96$, Kr $= +96$ — all positive.

- Among these, Ne has the highest (most positive) EGE at 116 kJ mol^{-1} — even higher than He's 48.

[Ans] Final Answer

Option (3) — IE decreases steadily He→Kr; all EGE values are positive; Ne shows the highest positive EGE (116 kJ mol^{-1}), higher than He.

[!] Common Mistake

Don't assume EGE trends must mirror IE trends smoothly — Ne being higher than He is an exception worth memorising directly from the data.

SKILL: Time Management and Strategic Thinking

Q10 — Correct Option: (2)

[A] Conceptual Approach (Hinglish)

Statement III galat hai — noble gases ka EGE 'positive' hota hai, 'negative' nahi (Q9 table mein dekha tha). Baaki teen statements standard correct facts hain.

[S] Step-by-Step

- I: True — general config ns^2np^6 applies to all except He ($1s^2$).
- II: True — IE decreases down the group with increasing size (matches Q9).
- III: False — EGE values are large and *positive* (unfavourable), not negative.
- IV: True — atomic radii increase steadily down the group (matches Q8).

[Ans] Final Answer

Option (2) — I, II and IV only; statement III is false because noble gases have positive, not negative, electron gain enthalpies.

[!] Common Mistake

A common trap: students assume "stable configurations resist change" means EGE must be very negative — resisting change actually means EGE is positive (unfavourable to add an electron).

TOPIC 3 Physical Properties

(a)–(d) Physical State, Boiling Point, Melting Point & Density

Master Formulae & Key Concepts

- Noble gases: monoatomic, colourless, odourless, tasteless.
- Only weak London dispersion forces act between atoms — no dipoles, no H-bonds, no covalent network.
- MP, BP, density all increase down the group (stronger dispersion forces with larger, more polarisable atoms).
- He: BP $= 4.2$ K, lowest of any known substance; does not solidify at 1 atm (needs $\sim$25 atm) due to zero-point energy.
- He's smallest atomic size (120 pm) $\Rightarrow$ diffuses through rubber/glass/plastic.

SKILL: Analytical Ability

Q11 — Correct Option: (4)

[A] Conceptual Approach (Hinglish)

Noble gases monoatomic hote hain — inke beech na to dipole hai, na hydrogen bond, na koi covalent network. Sirf weak London dispersion forces hi inhe thoda saath rakhte hain, isliye bahut kam heat mein hi yeh alag ho jaate hain — matlab bahut low MP/BP.

[S] Step-by-Step

- Noble gas atoms exist independently (monoatomic) — no covalent bonding between atoms.
- No permanent dipole (non-polar) $\rightarrow$ no dipole-dipole forces; no H-bonding possible.
- Only weak, induced-dipole (London/dispersion) forces hold atoms together in solid/liquid state.
- Very little thermal energy needed to overcome these weak forces $\rightarrow$ exceptionally low MP/BP.

[Ans] Final Answer

Option (4) — Only weak dispersion forces act between monoatomic noble gas atoms, giving them very low melting and boiling points.

[!] Common Mistake

Don't confuse this with "diatomic molecules have low BP" — noble gases are monoatomic, not diatomic; the low BP comes from lack of any bonding, not molecular size.

SKILL: Conceptual Clarity

Q12 — Correct Option: (2)

[A] Conceptual Approach (Hinglish)

He ka atomic radius sabse chhota hai (120 pm, poore group mein sabse kam). Chhote size ki wajah se yeh rubber, glass, plastic jaisi materials ke microscopic pores se bhi nikal jaata hai — jo normal gases ke liye 'gas-tight' maana jaata hai.

[S] Step-by-Step

- He $= 120$ pm is the smallest atomic radius among all noble gases.
- Materials like rubber, glass, plastic have microscopic structural gaps, generally too small for most gases.
- Helium's exceptionally small size lets it slip through these gaps, unlike larger gas molecules.
- Causes practical issues like helium balloons deflating faster and He leaking from sealed containers.

[Ans] Final Answer

Option (2) — Helium's exceptionally small atomic size (120 pm, the smallest in the group) lets it diffuse through microscopic pores in rubber, glass, and plastics.

[!] Common Mistake

Don't attribute this to reactivity — helium is one of the least reactive elements; this is a purely physical/size-based phenomenon.

SKILL: Application Skills

Q13 Correct Option: (1)

[A] Conceptual Approach (Hinglish)

Differences nikaalo consecutive pairs ke: Ne$-$He$= 22.9$, Ar$-$Ne$= 60.1$, Kr$-$Ar$= 32.5$, Xe$-$Kr$= 45.3$, Rn$-$Xe$= 46.0$. Sabse bada jump Ne se Ar jaate waqt hai — 60.1 K ka.

[S] Step-by-Step

- He$\rightarrow$Ne: $27.1 - 4.2 = 22.9$ K
- Ne$\rightarrow$Ar: $87.2 - 27.1 = 60.1$ K $\leftarrow$ largest
- Ar$\rightarrow$Kr: $119.7 - 87.2 = 32.5$ K
- Kr$\rightarrow$Xe: $165.0 - 119.7 = 45.3$ K
- Xe$\rightarrow$Rn: $211 - 165.0 = 46.0$ K

[Ans] Final Answer

Option (1) — Argon shows the largest single increase in boiling point (60.1 K rise from neon to argon).

[!] Common Mistake

Don't confuse "highest boiling point overall" (Rn, 211 K) with "largest increase from the preceding element" — the question asks specifically for the increase.

SKILL: Diagram-Based Visual Literacy

Q14 — Correct Option: (3)

[A] Conceptual Approach (Hinglish)

Ne se Kr tak teeno properties (MP, BP, density) badhte jaate hain — bade atom, zyada dispersion forces. Helium ka MP table mein '–' isliye hai kyunki He normal atmospheric pressure pe solid banta hi nahi — high pressure chahiye.

[S] Step-by-Step

- MP: Ne (24.6) $<$ Ar (83.8) $<$ Kr (115.9) — increasing.
- BP: Ne (27.1) $<$ Ar (87.2) $<$ Kr (119.7) — increasing.
- Density: Ne (9.0×10^{-4}) $<$ Ar (1.8×10^{-3}) $<$ Kr (3.7×10^{-3}) — increasing.
- Helium shows no listed MP because it does not solidify at ordinary (1 atm) pressure even near absolute zero (zero-point energy); it needs $\sim$25 atm to solidify.

[Ans] Final Answer

Option (3) — MP, BP and density all increase from Ne to Kr due to strengthening dispersion forces with atomic size; helium has no listed MP because it doesn't solidify at normal atmospheric pressure.

[!] Common Mistake

Don't assume "no melting point listed" means missing data/an error — it reflects a genuine, well-known physical property of helium.

SKILL: Time Management and Strategic Thinking

Q15 — Correct Option: (4)

[A] Conceptual Approach (Hinglish)

Statement IV galat hai — Helium neon se zyada dense NAHI hai, balki kam dense hai (density table se: He $<$ Ne), aur isi wajah se He hi fast diffuse karta hai, slow nahi.

[S] Step-by-Step

- I: True — standard property: monoatomic, colourless, odourless, tasteless.
- II: True — matches Analytical Ability solution (only dispersion forces present).
- III: True — He (4.2 K) has the lowest boiling point of any known substance.
- IV: False — He (1.8×10^{-4}) $<$ Ne (9.0×10^{-4}) in density; He is less dense and diffuses faster, not slower, due to its smaller size.

[Ans] Final Answer

Option (4) — I, II and III only; statement IV is false since helium is less dense than neon and diffuses faster, not slower.

[!] Common Mistake

Don't assume a group trend continues without exception — always cross-check specific numeric data before accepting a statement as true.

TOPIC 4 Chemical Properties

(a) General — Inertness, Bartlett's Discovery & Compound Status

Master Formulae & Key Concepts

- Three reasons for inertness: filled valence shell + very high IE + large positive EGE.
- Bartlett (1962): $\text{IE}(O_2) = 1175 \text{ kJ mol}^{-1} \approx \text{IE(Xe)} = 1170 \text{ kJ mol}^{-1} \Rightarrow PtF_6$ oxidises Xe just as it oxidises O_2.
- Compound status: Xe (richest chemistry) $>$ Kr (only KrF_2 studied) $>$ Rn (radiotracer only, not isolated) $>$ He/Ne/Ar (no true compounds).

SKILL: Analytical Ability

Q16 — Correct Option: (2)

[A] Conceptual Approach (Hinglish)

Bartlett ne dekha tha ki PtF_6 ne O_2 ko oxidise karke $O_2^+PtF_6^-$ banaya tha. Jab usne dekha ki Xe aur O_2 ka ionisation enthalpy bilkul similar hai (1170 vs 1175 kJ/mol), usne socha — 'agar PtF_6 O_2 se electron nikaal sakta hai, to Xe se bhi nikaal sakta hai' — aur yeh sahi nikla.

[S] Step-by-Step

- Known fact: PtF_6 oxidises $O_2 \rightarrow O_2^{+}PtF_6^{-}$ (removes one electron from O_2).
- $IE_1(O_2) = 1175$ kJ mol^{-1}; $IE_1(Xe) = 1170$ kJ mol^{-1} — nearly identical.
- Bartlett's logical leap: PtF_6 should equally remove an electron from Xe (needing even slightly less energy).
- Reaction confirmed experimentally: $Xe + PtF_6 \rightarrow Xe^{+}PtF_6^{-}$, the first noble gas compound.

[Ans] Final Answer

Option (2) — Bartlett reasoned that since PtF_6 could oxidise O_2 (IE $\approx$ 1175 kJ mol^{-1}), it should also oxidise Xe (IE $\approx$ 1170 kJ mol^{-1}) — a prediction that succeeded.

[!] Common Mistake

Don't treat this as a random/trial-and-error discovery — it was a deliberate, quantitative prediction based on comparing ionisation enthalpies.

SKILL: Conceptual Clarity

Q17 — Correct Option: (1)

[A] Conceptual Approach (Hinglish)

NCERT ke teen reasons yaad rakho ek saath: (1) valence shell completely filled hai (He ke alawa sab ns^2np^6), (2) ionisation enthalpy bahut high hai, (3) electron gain enthalpy bahut positive hai. Teeno milke inhe bond banane se rokte hain.

[S] Step-by-Step

- Filled valence shell: ns^2np^6 (or $1s^2$ for He) is exceptionally stable.
- High IE: removing an electron requires very large energy (He's is the highest known).
- Large positive EGE: adding an electron is also energetically unfavourable.
- Together, these three factors explain resistance to chemical bonding under ordinary conditions.

[Ans] Final Answer

Option (1) — Completely filled valence configuration, very high ionisation enthalpy, and large positive electron gain enthalpy together account for noble gas inertness.

[!] Common Mistake

Don't cite only one factor (e.g. "high IE alone") — NCERT expects all three reasons together.

SKILL: Application Skills

Q18 — Correct Option: (2)

[A] Conceptual Approach (Hinglish)

Teeno ka status yaad rakho: Krypton — sirf KrF_2 achi tarah se study hui hai. Radon — compounds sirf radiotracer technique se identify hue hain, isolate nahi kiye ja sake. Helium — abhi tak koi true compound known hi nahi hai.

[S] Step-by-Step

- Krypton: only KrF_2 prepared and characterised in detail.
- Radon: due to radioactivity/short half-life, compounds like RnF_2 only inferred via radiotracer, never isolated.
- Helium: to date, no genuine He compound has been confirmed.

[Ans] Final Answer

Option (2) — Krypton: only KrF_2 studied in detail; Radon: compounds identified only by radiotracer technique, not isolated; Helium: no true compounds known.

[!] Common Mistake

Don't mix up krypton and radon's status — krypton HAS a studied compound, while radon's compounds are only inferred, never isolated.

SKILL: Diagram-Based Visual Literacy

Q19 — Correct Option: (1)

[A] Conceptual Approach (Hinglish)

Table clearly dikhata hai — Xenon ki chemistry sabse rich hai (Bartlett ke discovery ke baad se), jabki He, Ne, Ar ki koi confirmed compound nahi hai, aur Kr/Rn ki chemistry bahut limited/unconfirmed hai.

[S] Step-by-Step

- Xe: many F and O compounds confirmed after 1962 (post-Bartlett) — richest chemistry.
- He, Ne, Ar: "No true compounds known" — zero confirmed chemistry.
- Kr: only KrF_2 studied in detail — very limited chemistry.
- Rn: compounds only inferred via radiotracer, never isolated — unconfirmed chemistry.

[Ans] Final Answer

Option (1) — Xenon has by far the richest known chemistry among noble gases, while He/Ne/Ar have none, and Kr/Rn have very limited or unconfirmed chemistry.

[!] Common Mistake

Don't assume "middle of the group = most reactive" — reactivity here is governed by ionisation enthalpy matching (Xe's, not Kr's), not by group position.

SKILL: Time Management and Strategic Thinking

Q20 — Correct Option: (3)

[A] Conceptual Approach (Hinglish)

Statement III galat hai — Radon ke compounds fully isolate nahi hue hain, sirf radiotracer se identify hue hain. Baaki teen statements historical/factual details hain jo sahi hain.

[S] Step-by-Step

- I: True — Bartlett prepared $Xe^{+}PtF_6^{-}$ in March 1962, the first noble gas compound.
- II: True — reasoning based on near-identical IE of O_2 (1175) and Xe (1170) kJ mol^{-1}.
- III: False — Rn compounds only inferred via radiotracer; never isolated/fully characterised.
- IV: True — no true compounds of Ar, Ne, or He are known.

[Ans] Final Answer

Option (3) — I, II and IV only; statement III is false since radon compounds have not been isolated, only detected via radiotracer methods.

[!] Common Mistake

Detection $\neq$ isolation — knowing radon reacts is not the same as having isolated and characterised its compounds.

(b) Xenon-Fluorine Compounds

Master Formulae & Key Concepts

- Prep: XeF_2 (673 K, 1 bar, Xe excess); XeF_4 (873 K, 7 bar, 1:5); XeF_6 (573 K, 60–70 bar, 1:20).
- Shapes (VSEPR): XeF_2 — linear (3 lp); XeF_4 — square planar (2 lp); XeF_6 — distorted octahedral (1 lp, gas phase).
- XeF_2 hydrolysis: $2XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$ (Xe reduced $+2 \rightarrow 0$; O oxidised $-2 \rightarrow 0$).
- XeF_6 + alkali metal fluorides (F^- donors) $\rightarrow$ anionic $[XeF_7]^-$; XeF_6 + $PF_5/AsF_5/SbF_5$ (F^- acceptors) $\rightarrow$ cationic $[XeF_5]^+$.

SKILL: Analytical Ability

Q21 Correct Option: (4)

[A] Conceptual Approach (Hinglish)

XeF_6 mein Xe ke saath 6 fluorine atoms attach karne hain — isliye reaction mixture mein F_2 ka bahut zyada excess (1:20 ratio) aur high pressure chahiye taaki equilibrium fully-fluorinated product ki taraf shift ho. Kam temperature product ko stable rakhne mein help karta hai.

[S] Step-by-Step

- Forming XeF_6 requires attaching 6 F atoms per Xe — most fluorine-rich xenon fluoride.
- Large excess F_2 (1:20) and high pressure (60–70 bar) push equilibrium toward complete fluorination.
- Lower temperature (573 K vs. 673 K/873 K for the others) favours stability of XeF_6 once formed.

[Ans] Final Answer

Option (4) — A large excess of F_2 and high pressure drive the equilibrium toward full fluorination (XeF_6); the lower temperature helps stabilise the product once formed.

[!] Common Mistake

Don't assume "higher pressure = prevents gas escaping" — the actual reason is shifting the reaction equilibrium (Le Chatelier's principle), not containment.

SKILL: Conceptual Clarity

Q22 Correct Option: (3)

[A] Conceptual Approach (Hinglish)

XeF_2 paani ke traces se bhi turant react kar jaata hai — matlab yeh moisture-sensitive hai. Isme Xe khud reduce hoke elemental Xe(0) ban jaata hai, jabki paani ka O_2 mein oxidise ho jaata hai — yani XeF_2 ek fluorinating/oxidising agent ki tarah behave karta hai.

[S] Step-by-Step

- Reaction: $2XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$
- Xe: $+2 \rightarrow 0$ (reduced). O: $-2 \rightarrow 0$ (oxidised).
- Since XeF_2 oxidises water's oxygen while being itself reduced, it acts as an oxidising/fluorinating agent.

[Ans] Final Answer

Option (3) — XeF_2 is highly moisture-sensitive and acts as a powerful fluorinating/oxidising agent, being itself reduced to elemental Xe while oxidising water to O_2.

[!] Common Mistake

Don't call XeF_2 a "reducing agent" just because it loses fluorine — Xe's oxidation number *decreases* ($+2 \rightarrow 0$), meaning XeF_2 itself is reduced, i.e. it is the oxidising agent.

SKILL: Application Skills

Q23 — Correct Option: (4)

[A] Conceptual Approach (Hinglish)

Lone pairs count karo Xe pe: XeF_2 mein 3 lone pairs + 2 bond pairs = linear. XeF_4 mein 2 lone pairs + 4 bond pairs = square planar. XeF_6 mein 1 lone pair + 6 bond pairs = distorted octahedral.

[S] Step-by-Step

- XeF_2: 5 electron pairs (2 bp + 3 lp) → trigonal bipyramidal e^- geometry, lone pairs equatorial → linear shape.
- XeF_4: 6 electron pairs (4 bp + 2 lp) → octahedral e^- geometry, lone pairs trans → square planar shape.
- XeF_6: 7 electron pairs (6 bp + 1 lp) → distorted octahedral shape (confirmed in gas phase).

[Ans] Final Answer

Option (4) — XeF_2: linear (3 lone pairs); XeF_4: square planar (2 lone pairs); XeF_6: distorted octahedral (1 lone pair, gas phase).

[!] Common Mistake

Don't swap XeF_2 and XeF_4's shapes — as bonding pairs increase ($2 \rightarrow 4 \rightarrow 6$), lone pairs decrease ($3 \rightarrow 2 \rightarrow 1$).

SKILL: Diagram-Based Visual Literacy

Q24 — Correct Option: (2)

[A] Conceptual Approach (Hinglish)

Fluorine ka proportion aur pressure dono badhte jaate hain jaise-jaise hum XeF_2 se XeF_6 ki taraf jaate hain. Lekin temperature ka trend seedha nahi hai — XeF_4 sabse high temp (873K) pe banta hai, XeF_6 sabse kam (573K) pe.

[S] Step-by-Step

- F_2 ratio: Xe-excess → 1:5 → 1:20 — steadily increasing.
- Pressure: 1 bar → 7 bar → 60–70 bar — steadily increasing.

- Temperature: 673 K $\rightarrow$ 873 K $\rightarrow$ 573 K — NOT monotonic.

[Ans] Final Answer

Option (2) — Pressure and F_2 proportion increase steadily from XeF_2 to XeF_6, but temperature does not follow a simple increasing trend.

[!] Common Mistake

Don't assume all three variables (T, P, ratio) must move together — read each column of the table independently.

SKILL: Time Management and Strategic Thinking

Q25 — Correct Option: (1)

[A] Conceptual Approach (Hinglish)

Statement IV mein galti hai — XeF_6 alkali metal fluorides (NaF, KF, RbF, CsF) ke saath ANIONIC species $[XeF_7]^-$ banata hai, cationic $[XeF_5]^+$ nahi. Cationic species F^--acceptors (PF_5, AsF_5, SbF_5) ke saath banta hai.

[S] Step-by-Step

- I: True — xenon fluorides are colourless crystalline solids, sublime readily, strong fluorinating agents.
- II: True — XeF_6 has 7 e^- pairs (6 bp + 1 lp), distorted octahedral in gas phase.
- III: True — matches XeF_2 hydrolysis reaction.
- IV: False — $XeF_6 + MF \longrightarrow M^+[XeF_7]^-$ is anionic; cationic $[XeF_5]^+$ forms instead with F^- acceptors like $PF_5/AsF_5/SbF_5$.

[Ans] Final Answer

Option (1) — I, II and III only; statement IV incorrectly assigns a cationic product to the alkali-metal-fluoride reaction, which actually gives the anionic $[XeF_7]^-$ species.

[!] Common Mistake

Classic NCERT trap: match "fluoride donor" reactions (alkali metal fluorides) to anionic products, and "fluoride acceptor" reactions ($PF_5/AsF_5/SbF_5$) to cationic products.

(c) Xenon-Oxygen Compounds

Master Formulae & Key Concepts

- $6XeF_4 + 12H_2O \rightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$ — disproportionation (Xe: $+4 \rightarrow 0$ and $+6$).
- $XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$ — complete hydrolysis, Xe stays $+6$, not redox.
- Partial hydrolysis: $XeF_6 + H_2O \rightarrow XeOF_4 + 2HF$; $XeF_6 + 2H_2O \rightarrow XeO_2F_2 + 4HF$.
- XeO_3: colourless explosive **SOLID**, pyramidal. $XeOF_4$: colourless volatile **LIQUID**, square pyramidal.

SKILL: Analytical Ability

Q26

Correct Option: (1)

[A] Conceptual Approach (Hinglish)

XeF_4 mein Xe $+4$ state mein hai — yeh state paani ke saath stable nahi rehta, isliye kuch Xe reduce hoke 0 ban jaata hai aur kuch oxidise hoke $+6$ ban jaata hai (XeO_3) — yeh hi disproportionation hai. XeF_6 mein Xe already $+6$ pe hai, to bas F ki jagah O le leta hai, oxidation state change hi nahi hota.

[S] Step-by-Step

- $6XeF_4 + 12H_2O \rightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$: Xe starts $+4$; some ends at 0 (reduced), some at $+6$ (oxidised) — classic disproportionation.
- $XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$: Xe starts and ends at $+6$ — no oxidation-state change, simple ligand exchange.
- Key factor: $+4$ is an unstable intermediate state for Xe in water; $+6$ is already a stable end-state.

[Ans] Final Answer

Option (1) — XeF_4 (Xe $= +4$) disproportionates into Xe(0) and Xe($+6$) on hydrolysis because $+4$ is an unstable intermediate state; XeF_6 (already Xe $= +6$) simply exchanges F for O with no oxidation-state change.

[!] Common Mistake

Don't judge disproportionation by the number of fluorine atoms present — it depends entirely on Xe's oxidation state in the starting compound.

SKILL: Conceptual Clarity

Q27

Correct Option: (3)

[A] Conceptual Approach (Hinglish)

Yaad rakho ulta na ho jaaye: XeO_3 SOLID hai (explosive bhi!) aur pyramidal shape ki hai. $XeOF_4$ LIQUID hai (volatile) aur square pyramidal shape ki hai.

[S] Step-by-Step

- XeO_3: Xe bonded to 3 O + 1 lone pair $\rightarrow$ pyramidal; colourless, explosive SOLID.
- $XeOF_4$: Xe bonded to 4 F + 1 O + 1 lone pair $\rightarrow$ square pyramidal; colourless, volatile LIQUID.

[Ans] Final Answer

Option (3) — XeO_3: colourless explosive solid, pyramidal structure; $XeOF_4$: colourless volatile liquid, square pyramidal structure.

[!] Common Mistake

Most common error: swapping which compound is the "liquid" and which is the "solid" — XeO_3 = solid (explosive!), $XeOF_4$ = liquid (volatile).

SKILL: Application Skills

Q28 Correct Option: (4)

[A] Conceptual Approach (Hinglish)

Jitna zyada paani doge, utna zyada F ki jagah O lega. 1 mole paani se sirf 1 O aata hai (2 F hatke) $\rightarrow$ $XeOF_4$. 2 mole paani se 2 O aate hain (4 F hatke) $\rightarrow$ XeO_2F_2. Pattern seedha hai: paani badhao, oxygen substitution badhao.

[S] Step-by-Step

- $XeF_6 + H_2O \rightarrow XeOF_4 + 2HF$: 1 H_2O replaces 2 F with 1 O, releasing 2 HF.
- $XeF_6 + 2H_2O \rightarrow XeO_2F_2 + 4HF$: 2 H_2O replace 4 F with 2 O, releasing 4 HF.
- Pattern: each additional mole of water substitutes one more O for two more F.

[Ans] Final Answer

Option (4) — 1 mol H_2O gives $XeOF_4$ (2 HF released); 2 mol H_2O gives XeO_2F_2 (4 HF released) — progressively more O-for-F substitution as water increases.

[!] Common Mistake

Don't reverse the stoichiometry — more water always means MORE oxygen substitution, not less.

SKILL: Diagram-Based Visual Literacy

Q29 Correct Option: (1)

[A] Conceptual Approach (Hinglish)

Ek clear pattern dikhta hai table mein: jaise-jaise lone pairs kam hote hain Xe pe ($3 \to 2 \to 1$), geometry badalti jaati hai — linear $\to$ square planar $\to$ distorted octahedral. $XeOF_4$ aur XeO_3 bhi isi lone-pair-logic se apni shape paate hain.

[S] Step-by-Step

- XeF_2 (3 lp) $\to$ linear; XeF_4 (2 lp) $\to$ square planar; XeF_6 (1 lp) $\to$ distorted octahedral.
- $XeOF_4$ (1 lp, 4F+1O) $\to$ square pyramidal.
- XeO_3 (1 lp, 3O) $\to$ pyramidal (same logic as NH_3's shape).

[Ans] Final Answer

Option (1) — Fewer lone pairs correspond to progressively different geometries (linear $\to$ square planar $\to$ distorted octahedral); $XeOF_4$ and XeO_3 both reflect one lone pair with mixed/single ligand types giving square pyramidal and pyramidal shapes respectively.

[!] Common Mistake

Don't assume more bonded atoms always means a "more regular" shape — XeF_6 is distorted precisely because of its lone pair, not despite it.

SKILL: Time Management and Strategic Thinking

Q30 Correct Option: (4)

[A] Conceptual Approach (Hinglish)

Statement III mein galti hai — XeO_3 ek SOLID hai (explosive), 'volatile liquid' nahi. Yeh property $XeOF_4$ ki hai, XeO_3 ki nahi.

[S] Step-by-Step

- I: True — complete hydrolysis of XeF_6 gives XeO_3 (Xe stays +6, non-redox).
- II: True — 1 mol water $\to$ $XeOF_4$; 2 mol water $\to$ XeO_2F_2.
- III: False — XeO_3 is a colourless EXPLOSIVE SOLID, not a volatile liquid; that description fits $XeOF_4$.
- IV: True — $XeOF_4$ is indeed a colourless volatile liquid with square pyramidal structure.

[Ans] Final Answer

Option (4) — I, II and IV only; statement III wrongly describes XeO_3 (actually an explosive solid) as a volatile liquid.

[!] Common Mistake

Same solid/liquid mix-up as the previous Conceptual Clarity question — keep the pairing fixed: XeO_3 = solid, $XeOF_4$ = liquid.

NCERT Examples (7.20–7.22) & In-Text Questions (7.32–7.34)

Master Formulae & Key Concepts

- Redox check: compare oxidation states of every atom before/after; unchanged $\Rightarrow$ not redox.
- In XeF_6 hydrolysis products ($XeOF_4$, XeO_2F_2): Xe $= +6$, F $= -1$, O $= -2$ throughout $\Rightarrow$ not redox.
- ^{222}Rn: $t_{1/2} \approx 3.8$ days $\Rightarrow$ decays before compounds can be isolated; studied only via radiotracer.
- "Noble" gas naming parallels "noble metals" — chemically inert due to stable filled shells.

SKILL: Analytical Ability

Q31 Correct Option: (3)

[A] Conceptual Approach (Hinglish)

Balance karne ke liye O aur H count match karo. Product mein XeO_2F_2 hai matlab 2 oxygen chahiye Xe pe — woh 2 H_2O se aayenge. 2 H_2O se 4 H milte hain, jo 4 HF banayenge.

[S] Step-by-Step

- Left side (with 2 H_2O): 1 Xe, 6 F, 4 H, 2 O.
- Right side (XeO_2F_2 + 4HF): Xe$= 1$; O$= 2$; F$= 2 + 4 = 6$; H$= 4$ — all balance.

[Ans] Final Answer

Option (3) — $XeF_6 + 2H_2O \rightarrow XeO_2F_2 + 4HF$ is the correctly balanced equation.

[!] Common Mistake

Don't confuse this with the complete hydrolysis equation ($XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$), which uses 3 mol water for a different product.

SKILL: Conceptual Clarity

Q32 Correct Option: (2)

[A] Conceptual Approach (Hinglish)

Redox check karne ka simple tareeka: har element ka oxidation state pehle aur baad mein compare karo. Yahan Xe $(+6)$, F (-1), O (-2) — sab reactant aur product dono mein same rehte hain. Koi bhi change nahi, isliye yeh redox reaction nahi hai.

[S] Step-by-Step

- In XeF_6: Xe $= +6$, F $= -1$.
- In $XeOF_4$ and XeO_2F_2: Xe remains $+6$, F remains -1, O $= -2$ (same as in water).
- No atom's oxidation state changes $\Rightarrow$ no oxidation and no reduction.

[Ans] Final Answer

Option (2) — No, this hydrolysis is not a redox reaction; Xe stays at $+6$, F stays at -1, and O stays at -2 throughout — no oxidation-state changes.

[!] Common Mistake

Don't assume "fluorine is being replaced" automatically implies redox — ligand replacement without oxidation-state change is not redox.

SKILL: Application Skills

Q33 Correct Option: (3)

[A] Conceptual Approach (Hinglish)

Radon radioactive hai aur uska sabse stable isotope (^{222}Rn) sirf $\sim$3.8 din mein half decay ho jaata hai. Itni jaldi decay hone ki wajah se koi bhi compound properly prepare, isolate aur characterize karne ka time hi nahi milta.

[S] Step-by-Step

- Radon is intensely radioactive; longest-lived isotope ^{222}Rn has $t_{1/2} \approx 3.8$ days.
- Typical synthesis/purification/characterisation often takes longer than this — the sample decays away first.
- This is why radon compounds are known only via radiotracer technique, not direct isolation.

[Ans] Final Answer

Option (3) — Radon is highly radioactive with a short half-life ($\sim$3.8 days for ^{222}Rn), leaving too little time to prepare, isolate, and characterise its compounds in detail.

[!] Common Mistake

Don't confuse this with a "chemical unreactivity" argument — the difficulty is due to radioactive instability of the atom, not a lack of chemical reactivity.

SKILL: Diagram-Based Visual Literacy

Q34 — Correct Option: (2)

[A] Conceptual Approach (Hinglish)

In-text sab jawaab ek hi jad se nikalte hain — completely filled valence shell. Isi wajah se noble gases monoatomic rehte hain (dispersion forces hi hoti hain → low BP), aur isi wajah se chemically bahut kam react karte hain (noble/inert behaviour).

[S] Step-by-Step

- Filled valence shell (ns^2np^6, or $1s^2$ for He) is the common root cause behind both observations.
- Atoms don't need to bond → monoatomic → only weak dispersion forces → low MP/BP.
- Same filled-shell stability → resistance to bonding → "noble"/inert chemical behaviour.

[Ans] Final Answer

Option (2) — Both the low boiling points and the "noble gas" name trace back to the same root cause: completely filled valence shells, which make the atoms monoatomic (→ weak dispersion forces → low BP) and chemically unreactive (→ noble behaviour).

[!] Common Mistake

Don't treat "low boiling point" and "chemical inertness" as unrelated facts — linking them to the same underlying cause makes recall far easier.

SKILL: Time Management and Strategic Thinking

Q35 — Correct Option: (1)

[A] Conceptual Approach (Hinglish)

Statement III galat hai — Radon study karna mushkil hai kyunki woh radioactive hai aur jaldi decay ho jaata hai, 'highly reactive' hone ki wajah se nahi. Baaki teen statements pichle questions se directly confirm hote hain.

[S] Step-by-Step

- I: True — balanced equation $XeF_6 + 2H_2O \rightarrow XeO_2F_2 + 4HF$, not a redox reaction.
- II: True — noble gases are monoatomic with only weak dispersion forces $\rightarrow$ very low BP.
- III: False — Radon's difficulty stems from radioactivity/short half-life, NOT from being "highly reactive."
- IV: True — filled valence shells make noble gases react only under special conditions.

[Ans] Final Answer

Option (1) — I, II and IV only; statement III incorrectly attributes radon's study difficulty to high reactivity instead of its radioactive instability.

[!] Common Mistake

A repeated trap across this DPP — don't confuse "hard to isolate due to short-lived radioactivity" with "hard to study due to high chemical reactivity."

Quick Answer Key

Q	Q	Q	Q	Q	Q	Q
1: (3)	2: (4)	3: (2)	4: (1)	5: (3)	6: (4)	7: (2)
8: (1)	9: (3)	10: (2)	11: (4)	12: (2)	13: (1)	14: (3)
15: (4)	16: (2)	17: (1)	18: (2)	19: (1)	20: (3)	21: (4)
22: (3)	23: (4)	24: (2)	25: (1)	26: (1)	27: (3)	28: (4)
29: (1)	30: (4)	31: (3)	32: (2)	33: (3)	34: (2)	35: (1)

"Noble gases don't react with much — but they will absolutely react with your marks if you skip the oxidation-state logic. Master the $+2$, $+4$, $+6$ *states of Xe, and even xenon will bow to you."*

— Your Weird Chemist