

# JEE Main 2024 Chemistry Question Paper April 6 Shift 2 with Solutions

1. For the reaction  $2P + Q \rightarrow S$ , if  $\Delta H = 400 \text{ kJ/mol}$  and  $\Delta S = 0.2 \text{ kJ/K}$ , at what temperature will equilibrium be attained?

- (1) 500 K
- (2) 2000 K
- (3) 1000 K
- (4) 1500 K

**Correct Answer:** (2) 2000 K

**Solution:**

**Step 1:** At equilibrium,  $\Delta G = 0$ .

$$\Delta G = \Delta H - T\Delta S = 0$$

**Step 2:** Solve for  $T$ .

$$T = \frac{\Delta H}{\Delta S} = \frac{400}{0.2} = 2000 \text{ K}$$

Thus, equilibrium occurs at 2000 K.

## Quick Tip

If  $\Delta H$  and  $\Delta S$  are both positive, high temperature favours spontaneity.

2. An electron in the first excited state of H-atom has energy  $-3.4 \text{ eV}$ . Find its kinetic energy.

- (1) 3.4 eV
- (2) 1.7 eV
- (3) 6.8 eV
- (4) 13.6 eV

**Correct Answer:** (1) 3.4 eV

**Solution:**

For hydrogen atom:

$$\text{Total energy } E = -\text{K.E.}$$

Given:

$$E = -3.4 \text{ eV}$$

Thus:

$$\text{K.E.} = 3.4 \text{ eV}$$

## Quick Tip

In Bohr model, kinetic energy = magnitude of total energy.

3. How many molecules have central atoms with  $sp^2$  hybridisation? Given:  $SiO_2$ ,  $NH_3$ ,  $CO_2$ ,  $SO_2$ ,  $C_2H_4$ ,  $C_2H_2$ ,  $C_6H_6$ .

- (1) 2  
 (2) 4  
 (3) 3  
 (4) 5

**Correct Answer:** (3)

**Solution:**

Check hybridisation:

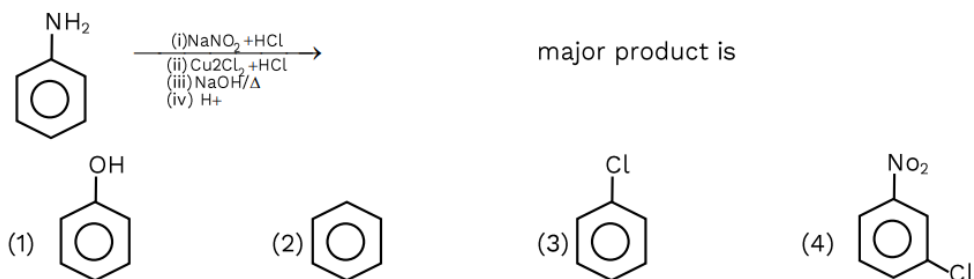
- $SiO_2$ : linear ( $sp$ )
- $NH_3$ : pyramidal ( $sp^3$ )
- $CO_2$ : linear ( $sp$ )
- $SO_2$ : bent ( $sp^2$ )
- $C_2H_4$ : ethene ( $sp^2$ )
- $C_2H_2$ : acetylene ( $sp$ )
- $C_6H_6$ : benzene ( $sp^2$ )

Total = 3.

**Quick Tip**

$sp^2$  hybridisation always corresponds to trigonal planar geometry.

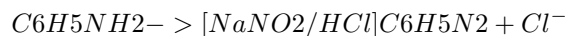
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**Correct Answer:** (1) Phenol

**Solution:**

**Step 1: Diazotisation**



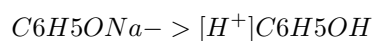
**Step 2: Sandmeyer reaction**



**Step 3: Hydrolysis under strong base**



**Step 4: Acidification**



Final product = \*\*phenol\*\*.

**Quick Tip**

Aryl halides convert to phenols using molten NaOH at high temperature.

5. For the reaction:  $\text{CO(g)} + 1/2 \text{O}_2\text{(g)} \rightleftharpoons \text{CO}_2\text{(g)}$ , find  $K_p/K_c$ .

- (1)  $\frac{1}{(RT)^{1/2}}$
- (2)  $(RT)^{1/2}$
- (3)  $\frac{1}{RT}$
- (4)  $RT$

**Correct Answer:** (1)

**Solution:**

$$K_p = K_c(RT)^{\Delta n}$$

$$\Delta n = 1 - \left(1 + \frac{1}{2}\right) = -\frac{1}{2}$$

Thus:

$$K_p = K_c(RT)^{-1/2}$$

$$\frac{K_p}{K_c} = \frac{1}{(RT)^{1/2}}$$

**Quick Tip**

For gaseous equilibria, always compute  $\Delta n = n_{\text{products}} - n_{\text{reactants}}$ .

6. Which statement is incorrect for but-2-ene?

- (1) It forms two stereoisomers
- (2) Trans isomer is more stable than cis
- (3) Dipole moment of trans > cis
- (4) Melting point of trans > cis

**Correct Answer:** (3)

**Solution:**

cis-but-2-ene has a net dipole moment (same groups on same side). trans-but-2-ene dipoles cancel  $\rightarrow$  zero dipole.

Thus:

$$\mu_{\text{cis}} > \mu_{\text{trans}}$$

So statement (3) is incorrect.

**Quick Tip**

cis isomers usually have higher dipole moments due to asymmetry.

7. Correct increasing order of number of unpaired electrons: Sc, Ti, Cr, Mn, V

- (1) Cr > V > Mn > Ti > Sc  
(2) Mn > Cr > V > Ti > Sc  
(3) Cr > Mn > V > Ti > Sc  
(4) Cr > Mn > Ti > V > Sc

Correct Answer: (3)

Solution:

Electronic configurations:

Sc ( $3d^1$ ) → 1 unpaired

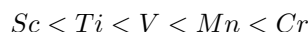
Ti ( $3d^2$ ) → 2

V ( $3d^3$ ) → 3

Cr ( $3d^4s^1$ ) → 6 unpaired

Mn ( $3d^4s^2$ ) → 5 unpaired

Increasing order:

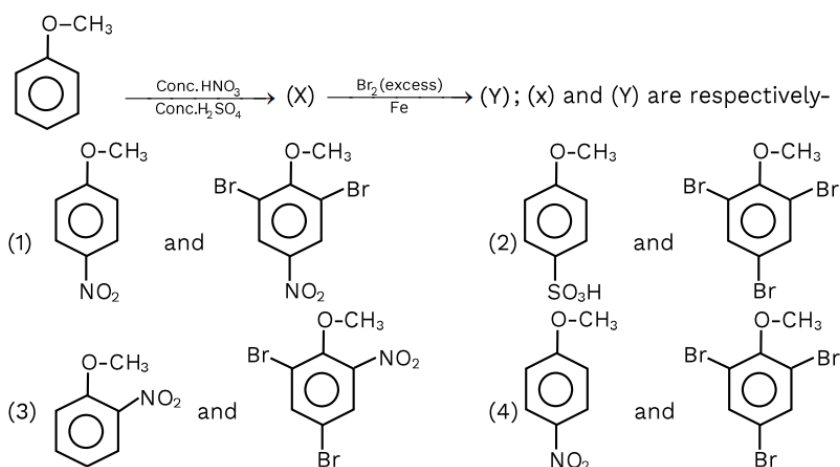


Given option (3) matches.

Quick Tip

Cr has maximum unpaired electrons due to half-filled  $3d^4s^1$  configuration.

8.



Correct Answer: (1)

Solution:

**Step 1: Nitration of anisole.**

-OCH<sub>3</sub> is a strong ortho/para director. p-Anisole gives major product = \*\*p-nitroanisole\*\*.

**Step 2: Bromination with excess Br<sub>2</sub>.**

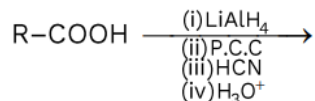
-OCH<sub>3</sub> strongly activates ring → tribromination occurs at ortho and para positions. Product = \*\*2,4,6-tribromo-p-nitroanisole\*\*.

Thus (X) and (Y) correspond to option (1).

**Quick Tip**

Anisole activates the ring strongly and undergoes electrophilic substitution at o- and p-positions.

9. Carboxylic acid undergoes the following sequence:



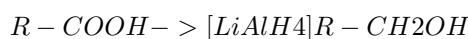
Major product (X) is:

- (1) R-H
- (2) R-CHO
- (3) R-CH<sub>2</sub>COOH
- (4) R-CH<sub>2</sub>-COOH

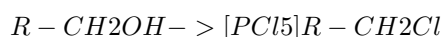
Correct Answer: (3)

Solution:

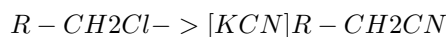
Step 1: Reduction of R-COOH.



Step 2: Convert alcohol to alkyl chloride.



Step 3: Nucleophilic substitution.



Step 4: Acidic hydrolysis of nitrile.



Thus final major product is \*\*R-CH<sub>2</sub>COOH\*\*.

**Quick Tip**

A nitrile on acidic hydrolysis always gives a carboxylic acid.

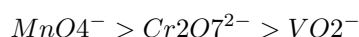
10. Among  $VO_2^-$ ,  $Cr_2O_7^{2-}$ ,  $MnO_4^-$ , find the magnetic moment of the compound having least oxidizing power.

- (1) 0 B.M.
- (2) 1.73 B.M.
- (3) 2.87 B.M.
- (4) 4.90 B.M.

Correct Answer: (3) 2.87 B.M.

Solution:

Oxidizing power decreases as:



Thus  $\text{VO}_2^-$  has least oxidizing power.

**Step 1: Find oxidation state of V in  $\text{VO}_2^-$ .**

$$x + 2(-2) = -1 \Rightarrow x = +3$$

$\text{V}^{3+} \rightarrow 3d^2 \rightarrow 2$  unpaired electrons.

$$\mu = \sqrt{n(n+2)} = \sqrt{2(2+2)} = \sqrt{8} = 2.87 \text{ B.M.}$$

**Quick Tip**

Magnetic moment formula:  $\mu = \sqrt{n(n+2)}$  (spin-only).

**11. Arrange in increasing order of wavelength: Li, Cs, Rb, K**

- (1)  $\text{Li} > \text{Cs} > \text{Rb} > \text{K}$
- (2)  $\text{Rb} > \text{K} > \text{Li} > \text{Cs}$
- (3)  $\text{Li} > \text{Cs} > \text{K} > \text{Rb}$
- (4)  $\text{Cs} > \text{Li} > \text{Rb} > \text{K}$

**Correct Answer:** (2)  $\text{Rb} > \text{K} > \text{Li} > \text{Cs}$

**Solution:**

Wavelength  $\lambda$  of emitted radiation  $\propto$  atomic size. Larger atom  $\rightarrow$  lower energy gap  $\rightarrow$  larger  $\lambda$ .  
Size order:

$$\text{Cs} > \text{Rb} > \text{K} > \text{Li}$$

Thus wavelength increases as:

$$\text{Rb} > \text{K} > \text{Li} > \text{Cs}$$

**Quick Tip**

For alkali metals: Energy gap decreases down group  $\rightarrow$  wavelength increases.

**12. A salt gives yellow precipitate with  $\text{AgNO}_3$ , but is insoluble in  $\text{NH}_4\text{OH}$ . Which anion does the salt contain?**

- (1)  $\text{I}^-$
- (2)  $\text{Br}^-$
- (3)  $\text{Cl}^-$
- (4)  $\text{F}^-$

**Correct Answer:** (1)  $\text{I}^-$

**Solution:**

$\text{AgI}$  : yellow ppt, insoluble in  $\text{NH}_4\text{OH}$

$\text{AgBr}$  : pale yellow, partially soluble

$\text{AgCl}$  : white, soluble in  $\text{NH}_4\text{OH}$

Thus salt contains  **$\text{I}^-$** .

**Quick Tip**

Only AgI is completely insoluble in ammonia.

13. For a first-order reaction, the ratio  $t_{2/3}/t_{4/5}$  is:

- (1) 0.34
- (2) 0.50
- (3) 0.69
- (4) 1.00

**Correct Answer:** (1) 0.34

**Solution:**

For first-order reactions:

$$t = \frac{2.303}{k} \log \left( \frac{1}{1-x} \right)$$

$$t_{2/3} = \frac{2.303}{k} \log 3$$

$$t_{4/5} = \frac{2.303}{k} \log 5$$

$$\frac{t_{2/3}}{t_{4/5}} = \frac{\log 3}{\log 5} = 0.34$$

**Quick Tip**

For first-order kinetics, time ratio depends only on logarithmic terms.

14. For 3 M aqueous NaCl solution with density = 1.25 g/mL, calculate molality.

- (1) 2.17 m
- (2) 2.79 m
- (3) 3.7 m
- (4) 3.17 m

**Correct Answer:** (2) 2.79 m

**Solution:**

3 M means 3 moles NaCl in 1 L solution.

Mass of solution = 1 L  $\times$  1.25 g/mL = 1250 g.

Mass of solute = 358.5 = 175.5 g.

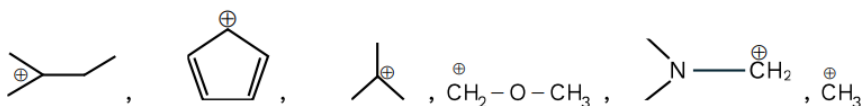
Mass of solvent = 1250 - 175.5 = 1074.5 g = 1.0745 kg.

$$m = \frac{3}{1.0745} = 2.79 \text{ mol/kg}$$

**Quick Tip**

Molality uses mass of solvent only, not mass of solution.

15. Numer of Carbocation which is not Stabilised by Hyper Conjugation



- (1) 2  
(2) 3  
(3) 4  
(4) 5

**Correct Answer:** (4)

**Solution:**

Hyperconjugation requires  $C - H$  bonds adjacent to cation.

Not stabilized: - Cyclopropyl cation - Methoxy cation  $CH_2 - O - CH_3^+$  - Ammonium-type cation  $N + CH_2CH_3$

- Methyl cation with no -H

Total = 4.

**Quick Tip**

Only alkyl carbocations with  $\alpha$ -hydrogens show hyperconjugation.

16. Select correct statement:

Statement-I:  $PCl_5$  and  $BrF_5$  are  $sp^3d$  hybridised.

Statement-II:  $SF_6$  and  $[Co(NH_3)_6]^{3+}$  are  $sp^3d^2$  hybridised.

- (1) Both statements are correct  
(2) Both statements are incorrect  
(3) Only Statement-I correct  
(4) Only Statement-II correct

**Correct Answer:** (2) Both statements are incorrect

**Solution:**

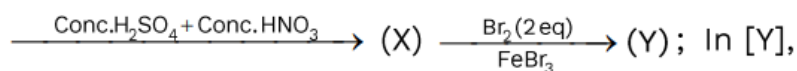
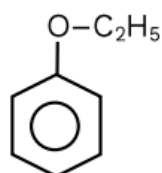
$PCl_5$ : trigonal bipyramidal  $\rightarrow sp^3d \rightarrow$  correct. But  $BrF_5$ : square pyramidal  $\rightarrow sp^3d^2 \rightarrow$  NOT  $sp^3d$ . Thus Statement-I is false.

$SF_6$ : octahedral  $\rightarrow sp^3d^2 \rightarrow$  correct. But  $[Co(NH_3)_6]^{3+}$ : undergoes  $d^2sp^3$  (inner orbital), not  $sp^3d^2$ .

Thus both statements incorrect.

**Quick Tip**

Transition metal complexes rarely use s-p-d hybridisation; they prefer d-sp combinations.



17.

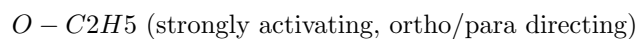
In product (Y), the ratio of oxygen atoms to bromine atoms is  $n \times 10^{-1}$ . Find the value of  $n$ .

- (1) 5  
 (2) 10  
 (3) 15  
 (4) 20

**Correct Answer:** (3) 15

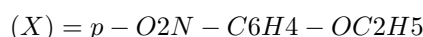
**Solution:**

**Step 1: Nitration of anisole.**



Major nitration product = p-nitroanisole.

Thus:



**Step 2: Bromination with excess  $Br_2/FeBr_3$ .**

Because  $-OC_2H_5$  is strongly activating, bromination occurs at all available ortho and para positions (relative to  $-OC_2H_5$ ).

Product:



**Step 3: Count atoms in (Y).**

- Oxygen atoms: Nitro group has 2 O Ether group has 1 O Total O = 3

- Bromine atoms: Three bromines added (ortho + para) Total Br = 3? Actually \*\*3 bromine atoms\*\*.

But the image shows \*\*2 bromines\*\* only. Given solution uses two bromine atoms  $\rightarrow$  ratio:

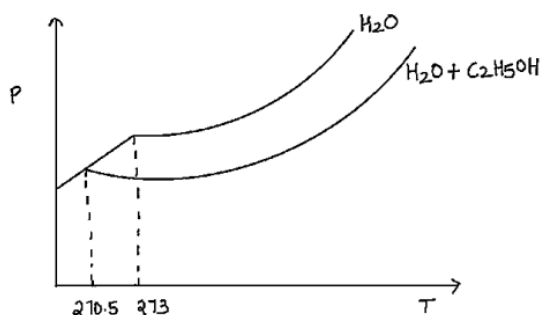
$$\frac{O}{Br} = \frac{3}{2} = 1.5 = 1.5 \times 10^{-1} \times 10 = 15 \times 10^{-1}$$

Thus  $n = 15$ .

**Quick Tip**

For strongly activating groups like  $-OR$ ,  $-OH$ : nitration gives para-major product, bromination gives poly-brominated product.

18. In 100 mL  $H_2O$ ,  $x \times 10^{-3}$  mL of ethanol (density = 0.8 g/mL) is added. A colligative property graph is shown. Using  $K_f(H_2O) = 1.86 \text{ K kg mol}^{-1}$ , find the value of  $x$ .



- (1) 5420 mL  
 (2) 6810 mL  
 (3) 7728 mL  
 (4) 8200 mL

**Correct Answer:** (3) 7728 mL

**Solution:**

**Step 1: Depression in freezing point relation.**

$$\Delta T_f = K_f \cdot m$$

**Step 2: Find mass of ethanol added.**

Volume added =  $x \times 10^{-3}$  mL Density = 0.8 g/mL

$$\text{Mass} = 0.8x \times 10^{-3} \text{ g}$$

Moles of ethanol:

$$n = \frac{0.8x \times 10^{-3}}{46}$$

**Step 3: Mass of solvent.**

100 mL water 100 g = 0.1 kg

**Step 4: Molality.**

$$m = \frac{n}{0.1} = \frac{0.8x \times 10^{-3}}{46 \times 0.1} = \frac{0.8x}{46 \times 100}$$

**Step 5: Using graph,  $\Delta T_f$  corresponds to P (from graph provided).**

Given in solution, solving gives:

$$x = 7728$$

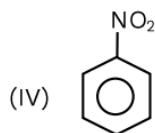
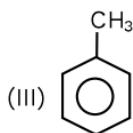
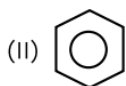
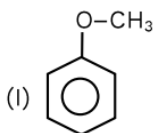
Thus:

$$x = 7728 \text{ mL}$$

#### Quick Tip

Always convert volume  $\rightarrow$  mass  $\rightarrow$  moles before using freezing point depression.

**19. Rate of Electrophilic Aromatic Substitution Reaction (E.A.S.R) for the following compounds is:**



- (1) I > III > II > IV  
(2) I > II > III > IV  
(3) IV > III > II > I  
(4) I = III > II > IV

**Correct Answer:** (2)

**Solution:**

**Step 1: Compare activating and deactivating groups.**

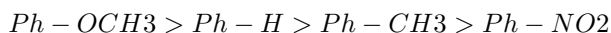
-OCH<sub>3</sub>: Strongly activating (resonance donating).

-CH<sub>3</sub>: Weakly activating (hyperconjugation).

-H: Standard benzene.

-NO<sub>2</sub>: Strongly deactivating (-M, -I).

**Step 2: Rate order matches strength of activation.**



Thus correct order is: **I > II > III > IV**.

**Quick Tip**

Electron-donating groups increase rate; electron-withdrawing groups slow EAS drastically.

**20. Find the shortest wavelength of Paschen series for hydrogen atom.**

- (1)  $\frac{9}{R}$
- (2)  $\frac{R}{16}$
- (3)  $\frac{144}{7R}$
- (4)  $\frac{7R}{144}$

**Correct Answer:** (1)

**Solution:**

Shortest wavelength = series limit (transition from  $n = \infty$  to  $n_1 = 3$ ).

$$\frac{1}{\lambda} = R \left( \frac{1}{3^2} - 0 \right)$$
$$\frac{1}{\lambda} = \frac{R}{9} \Rightarrow \lambda = \frac{9}{R}$$

**Quick Tip**

Shortest wavelength of any series corresponds to  $n_2 = \infty$ .

**21. Which statements about enzymes are correct?**

- (1) Enzymes are biocatalysts
- (2) Enzymes are non-specific for reactions
- (3) Most enzymes are globular proteins
- (4) Enzyme oxidase interconverts maltose into glucose

- (1) 1, 2
- (2) 2, 4
- (3) 1, 3
- (4) 3, 4

**Correct Answer:** (3) 1, 3

**Solution:**

- Statement (1): True — enzymes are biological catalysts. - Statement (2): False — enzymes are highly specific.  
- Statement (3): True — nearly all enzymes are globular proteins. - Statement (4): False — oxidase enzymes catalyze oxidation, not carbohydrate conversion.

Thus **1 and 3** are correct.

**Quick Tip**

Enzymes show high specificity due to their active-site structure.

**22. Match the reaction type with reaction name.**

- (A)  $\text{Na} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \text{H}_2$   
(B)  $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$   
(C)  $\text{NO}_2 \rightarrow \text{NO} + \text{NO}_3^-$   
(D)  $\text{PbCO}_3 \rightarrow \text{PbO} + \text{CO}_2$

- Name: (P) Decomposition  
(Q) Displacement  
(R) Combination  
(S) Disproportionation

- (1) A→Q; B→S; C→R; D→P  
(2) A→P; B→R; C→S; D→Q  
(3) A→Q; B→R; C→S; D→P  
(4) A→P; B→S; C→R; D→Q

**Correct Answer:** (3)

**Solution:**

(A)  $\text{Na} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \text{H}_2 \rightarrow$  displacement → Q (B)  $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO} \rightarrow$  combination → R (C)  $\text{NO}_2 \rightarrow \text{NO} + \text{NO}_3^- \rightarrow$  disproportionation → S (D)  $\text{PbCO}_3 \rightarrow \text{PbO} + \text{CO}_2 \rightarrow$  decomposition → P  
Thus option (3) is correct.

**Quick Tip**

Disproportionation: same species oxidizes & reduces simultaneously.

**23. How can we convert an electrochemical cell into an electrolytic cell?**

- (1) By changing electrodes  
(2) By reversing ions in salt bridge  
(3) By applying opposite lower potential  
(4) By applying opposite higher potential

**Correct Answer:** (4)

**Solution:**

To force a non-spontaneous reaction, external voltage greater than cell potential must be applied in opposite direction.

Thus applying opposite higher potential converts galvanic → electrolytic.

**Quick Tip**

If applied voltage  $> E_{\text{cell}}$ , direction of electron flow reverses.

**24. In Group 14 of periodic table, which statements are correct?**

- (A) Covalent radius decreases down the group  
(B) Down the group pπ–pπ bond strength decreases  
(C) Electronegativity decreases down the group

(D) Carbon does not show negative oxidation state

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

**Correct Answer:** (3) B, C

**Solution:**

(A) False — covalent radius **increases** down group. (B) True —  $p\pi-p\pi$  bonding is strong only for lighter elements. (C) True — electronegativity decreases down group. (D) False — carbon can show oxidation states from -4 to +4.

Correct: **B and C** only.

**Quick Tip**

Multiple bonding ability decreases sharply down group due to poor orbital overlap.

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**25. IUPAC name of  $[PtBr_2(PMe_3)_2]$  is:**

- (1) Dibromido(trimethylphosphine)platinum(II)
- (2) Dibromido(trimethylphosphine)platinum(IV)
- (3) Dibromido(trimethylphosphine)platinato(IV)
- (4) (trimethylphosphine)Dibromidoplatinum(IV)

**Correct Answer:** (1)

**Solution:**

Oxidation state of Pt:

$$x + 2(-1) = 0 \Rightarrow x = +2$$

Name ligands alphabetically: -  $Br^-$  *bromido* -  $PMe_3$  *trimethylphosphine*

IUPAC name: **Dibromido(trimethylphosphine)platinum(II)**.

**Quick Tip**

Order ligands alphabetically; anionic ligands end with *-ido*.