GATE Chemistry Revision Notes

Physical Chemistry Formula and Problem Solving Book

QUANTUM MODEL SELECTION

Definition :-

Match each problem to box, oscillator, rotor, hydrogenic atom or approximation method before using equations.

Deciding rule :-

Test energy sign, zero-point value and degeneracy.

Key relation :-

box n squared; oscillator v+1/2; rotor J(J+1); hydrogen -Z squared/n squared

GATE clue :-

Keywords about boundaries, vibration, rotation or Coulomb attraction identify the model.

Common mistake :-

Mixing quantum-number rules between models causes fast errors.

Worked cue :-

Use the recognition clue first. Begin with box n squared; oscillator v+1/2; rotor J(J+1); hydrogen -Z squared/n squared, then apply the deciding rule and reject the stated common mistake.

→ Rapid recall: Quantum model selection: T...

→ Mistake repair: Mixing quantum-number ru...

QUANTUM MODEL SELECTION : EXAM ROUTE

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Keywords about boundaries, vibration, rotation or Coulomb attraction identify the model.

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Match each problem to box, oscillator, rotor, hydrogenic atom or approximation method before using equations.

Working relation :-

box n squared; oscillator v+1/2; rotor J(J+1); hydrogen -Z squared/n squared

Solve in this order :

→ write the species, state or model clearly

→ mark symmetry, charge, spin and conditions

→ use the relation before inserting numbers

→ test dimensions and the extreme limit

Common mistake :-

Mixing quantum-number rules between models causes fast errors.

One-line decision :-

Test energy sign, zero-point value and degeneracy.

Bottom-line check :-

Verify the relation, condition and trend before accepting the answer.

→ Mini application: Quantum model selectio...

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OPERATOR AND EXPECTATION TOOLKIT

Definition :-

Operators represent observables; normalization, eigenvalue equations and expectation values control measurement predictions.

Deciding rule :-

Hermitian observables give real expectation values.

Key relation :-

A psi = a psi; average A = bracket psi A psi

GATE clue :-

Check whether the state is an eigenstate before claiming zero uncertainty.

Common mistake :-

An average value need not be one measurement outcome.

Final check :-

Confirm the result against the defining assumption, then test the sign, symmetry, charge or limiting chemical trend.

Worked cue :-

Use the recognition clue first. Begin with A psi = a psi; average A = bracket psi A psi, then apply the deciding rule and reject the stated common mistake.

Rapid recall :-

Operator and expectation toolkit: Hermitian observables give real expectation values.

OPERATOR AND EXPECTATION TOOLKIT : EXAM ROUTE

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→ Mini application: Operator and expectati...

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SPECTROSCOPY FORMULAS

Definition :-

Rotational, vibrational and electronic spectra use energy gaps, selection rules and transition moments.

Deciding rule :-

Heavier isotopes lower rotational and vibrational spacings.

Key relation :-

rotational spacing 2B; vibration frequency proportional root(k/mu)

GATE clue :-

Use symmetry and dipole change before calculating frequency.

Common mistake :-

An existing mode can be spectroscopically inactive.

Final check :-

Confirm the result against the defining assumption, then test the sign, symmetry, charge or limiting chemical trend.

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Spectroscopy formulas: Heavier isotopes lower rotational and vibrational spacings.

→ Rapid recall: Spectroscopy formulas: Hea...

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Mini application :-

Spectroscopy formulas: start from rotational spacing 2B; vibration frequency proportional root(k/mu).

THERMODYNAMIC IDENTITIES

Definition :-

Choose the potential whose natural variables match the process and use exact relations consistently.

Deciding rule :-

At equilibrium the appropriate potential is minimized.

Key relation :-

$$dG = VdP - SdT;\ \Delta G = \Delta H - T\Delta S$$

GATE clue :-

Mark T, P, V and composition constraints first.

Common mistake :-

A negative Delta G says nothing about rate.

Final check :-

Confirm the result against the defining assumption, then test the sign, symmetry, charge or limiting chemical trend.

Worked cue :-

Use the recognition clue first. Begin with $dG = VdP - SdT;\ \Delta G = \Delta H - T\Delta S$, then apply the deciding rule and reject the stated common mistake.

Rapid recall :-

Thermodynamic identities: At equilibrium the appropriate potential is minimized.

→ Rapid recall: Thermodynamic identities:...

→ Mistake repair: A negative Delta G says...

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→ Mini application: Thermodynamic identiti...

SOLUTION AND EQUILIBRIUM FORMULAS

Definition :-

Chemical potential, activity, fugacity and reaction quotient extend ideal equations to real mixtures.

Deciding rule :-

Compare Q with K for reaction direction.

Key relation :-

$$\mu = \mu^\circ + RT \ln a; \quad \Delta G = \Delta G^\circ + RT \ln Q$$

GATE clue :-

Define the standard state before inserting activity.

Common mistake :-

Raw concentration is not automatically a dimensionless activity.

Final check :-

Confirm the result against the defining assumption, then test the sign, symmetry, charge or limiting chemical trend.

Worked cue :-

Use the recognition clue first. Begin with $\mu = \mu^\circ + RT \ln a; \Delta G = \Delta G^\circ + RT \ln Q$, then apply the deciding rule and reject the stated common mistake.

Rapid recall :-

Solution and equilibrium formulas: Compare Q with K for reaction direction.

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Define the standard state before inserting activity.

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Solve in this order :

→ write the species, state or model clearly

→ mark symmetry, charge, spin and conditions

→ use the relation before inserting numbers

→ test dimensions and the extreme limit

Common mistake :-

Raw concentration is not automatically a dimensionless activity.

One-line decision :-

Compare Q with K for reaction direction.

Bottom-line check :-

Verify the relation, condition and trend before accepting the answer.

Correction cue :-

Raw concentration is not automatically a dimensionless activity. Instead, Compare Q with K for reaction direction.

ELECTROCHEMISTRY TOOLKIT

Definition :-

Cell potential, free energy, equilibrium and composition are connected through electron transfer number.

Deciding rule :-

At equilibrium E cell is zero and Q equals K.

Key relation :-

Delta G = -nFE; E = E standard - RT ln Q/nF

GATE clue :-

Balance the redox reaction before forming Q.

Common mistake :-

Do not multiply E standard by stoichiometric coefficients.

Final check :-

Confirm the result against the defining assumption, then test the sign, symmetry, charge or limiting chemical trend.

Worked cue :-

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Rapid recall :-

Electrochemistry toolkit: At equilibrium E cell is zero and Q equals K.

→ Rapid recall: Electrochemistry toolkit:...

→ Mistake repair: Do not multiply E standa...

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Mini application :-

Electrochemistry toolkit: start from Delta G = -nFE; E = E standard - RT ln Q/nF.

→ Mini application: Electrochemistry toolk...

PHASE EQUILIBRIUM TOOLKIT

Definition :-

Phase rule, Clapeyron slope, tie lines and lever rule organize phase-diagram questions.

Deciding rule :-

Use the opposite tie-line segment for phase fraction.

Key relation :-

$$F = C - P + 2;\ dP/dT = \text{Delta } H/(T \text{ Delta } V)$$

GATE clue :-

Identify components and phases at the chosen point.

Common mistake :-

Species count is not component count.

Final check :-

Confirm the result against the defining assumption, then test the sign, symmetry, charge or limiting chemical trend.

Worked cue :-

Use the recognition clue first. Begin with $F = C - P + 2;\ dP/dT = \text{Delta } H/(T \text{ Delta } V)$, then apply the deciding rule and reject the stated common mistake.

Rapid recall :-

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→ Rapid recall: Phase equilibrium toolkit:...

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Use the opposite tie-line segment for phase fraction.

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Mini application :-

Phase equilibrium toolkit: start from $F = C - P + 2$; $dP/dT = \Delta H/(T \Delta V)$.

→ Mini application: Phase equilibrium tool...

KINETIC RATE TOOLKIT

Definition :-

Integrated laws, steady state, Arrhenius and transition-state relations connect concentration and activation parameters to rate.

Deciding rule :-

Units of κ reveal overall order.

Key relation :-

$$\ln \kappa = \ln A - Ea/RT;\ \kappa = \kappa BT/h \exp(-\Delta G^{\ddagger}/RT)$$

GATE clue :-

Determine reaction order from evidence, not overall stoichiometry.

Common mistake :-

The slowest-looking equation is not always rate determining.

Final check :-

Confirm the result against the defining assumption, then test the sign, symmetry, charge or limiting chemical trend.

Worked cue :-

Use the recognition clue first. Begin with $\ln \kappa = \ln A - Ea/RT;\ \kappa = \kappa BT/h \exp(-\Delta G^{\ddagger}/RT)$, then apply the deciding rule and reject the stated common mistake.

Rapid recall :-

Kinetic rate toolkit: Units of κ reveal overall order.

KINETIC RATE TOOLKIT : EXAM ROUTE

Recognize the pattern :-

Determine reaction order from evidence, not overall stoichiometry.

Start from the concept :-

Integrated laws, steady state, Arrhenius and transition-state relations connect concentration and activation parameters to rate.

Working relation :-

ln k = ln A - Ea/RT; k = kBT/h exp(-Delta G double dagger/RT)

Solve in this order :

→ write the species, state or model clearly

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→ use the relation before inserting numbers

→ test dimensions and the extreme limit

Common mistake :-

The slowest-looking equation is not always rate determining.

One-line decision :-

Units of k reveal overall order.

Bottom-line check :-

Verify the relation, condition and trend before accepting the answer.

→ Mini application: Kinetic rate toolkit:...

→ Correction cue: The slowest-looking equa...

STATISTICAL MECHANICS TOOLKIT

Definition :-

Partition functions generate populations and thermodynamic quantities from microscopic energy levels.

Deciding rule :-

Low temperature emphasizes the ground manifold.

Key relation :-

$$q = \sum g \exp(-E/kT);\ U = kT^2\, d \ln q/dT$$

GATE clue :-

Separate independent translational, rotational, vibrational and electronic factors.

Common mistake :-

Degeneracy must be included in population ratios.

Final check :-

Confirm the result against the defining assumption, then test the sign, symmetry, charge or limiting chemical trend.

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Use the recognition clue first. Begin with $q = \sum g \exp(-E/kT);\ U = kT^2\, d \ln q/dT$, then apply the deciding rule and reject the stated common mistake.

Rapid recall :-

Statistical mechanics toolkit: Low temperature emphasizes the ground manifold.

→ Rapid recall: Statistical mechanics tool...

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Degeneracy must be included in population ratios.

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Low temperature emphasizes the ground manifold.

Bottom-line check :-

Verify the relation, condition and trend before accepting the answer.

Mini application :-

Statistical mechanics toolkit: start from $q = \sum g \exp(-E/kT)$; $U = kT^2 \, d \ln q/dT$.

SURFACE AND COLLOID TOOLKIT

Definition :-

Adsorption, capillarity, micelles and colloidal stability rely on coverage, interfaces and competing interactions.

Deciding rule :-

Strong adsorption can inhibit catalysis by site blocking.

Key relation :-

> Langmuir theta = KP/(1+KP); Delta P = 2 gamma/r

GATE clue :-

Check low- and high-pressure or concentration limits.

Common mistake :-

Empirical Freundlich behavior cannot predict saturation.

Final check :-

Confirm the result against the defining assumption, then test the sign, symmetry, charge or limiting chemical trend.

Worked cue :-

Use the recognition clue first. Begin with Langmuir theta = KP/(1+KP); Delta P = 2 gamma/r, then apply the deciding rule and reject the stated common mistake.

Rapid recall :-

Surface and colloid toolkit: Strong adsorption can inhibit catalysis by site blocking.

→ Rapid recall: Surface and colloid toolki...

→ Mistake repair: Empirical Freundlich beh...

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Mini application :-

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→ Mini application: Surface and colloid to...

CK RECALL : PHYSICAL CHEMISTRY FORMULA AND PROBLEM SOLVING

→ Quantum model selection : box n squared; oscillator v+1/2; ro...

→ Operator and expectati... : A psi = a psi; average A = bracket...

→ Spectroscopy formulas : rotational spacing 2B; vibration fr...

→ Thermodynamic identities : dG = VdP - SdT; Delta G = Delta H -...

→ Solution and equilibri... : mu = mu standard + RT ln a; Delta G...

→ Electrochemistry toolkit : Delta G = -nFE; E = E standard - RT...

→ Phase equilibrium toolkit : F = C - P + 2; dP/dT = Delta H/(T D...

→ Kinetic rate toolkit : ln k = ln A - Ea/RT; k = kBT/h exp(...

→ Statistical mechanics... : q = sum g exp(-E/kT); U = kT square...

→ Surface and colloid to... : Langmuir theta = KP/(1+KP); Delta P...

Recall method :-

Cover the right side, say the relation or deciding rule aloud, then verify it. Repeat weak rows after one hour.

Three-way recall :

→ say the definition without looking

→ write the relation and assumptions

→ name the most likely exam mistake

Final recall pair :-

Quantum model selection and Surface and colloid toolkit: connect both to their deciding relations.

Self-test :-

Explain Solution and equilibrium formulas in two lines, then state its common mistake.

GATE MISTAKES & FINAL CHECK

Physical Chemistry Formula and Problem Solving Book :-

→ Quantum model s... : Mixing quantum-number ru...

→ Operator and ex... : An average value need no...

→ Spectroscopy fo... : An existing mode can be...

→ Thermodynamic i... : A negative Delta G says...

→ Solution and eq... : Raw concentration is not...

→ Electrochemistr... : Do not multiply E standa...

→ Phase equilibri... : Species count is not com...

→ Kinetic rate to... : The slowest-looking equa...

→ Statistical mec... : Degeneracy must be inclu...

→ Surface and col... : Empirical Freundlich beh...

Before selecting the answer :-

→ check sign, units and order of magnitude

→ check charge, electron count and symmetry

→ separate kinetic from thermodynamic claims

→ verify whether an approximation is allowed

Final habit :-

Use the quickest decisive rule first. Calculate only when two options survive the conceptual checks.

Repair drill :-

The slowest-looking equation is not always rate determining. Correct rule: Units of k reveal overall order.

→ Repair drill: The slowest-looking equati...