CHEM 120 — Test 2 Cram Sheet

Scoped to the official LEARN blueprint · Modules 2–4

Wed Nov 11 · 45 min · in section
17 Q · bubble sheet · assigned seat
Look up your room + seat (new!)

Module 2 → 6 Q (§2.4 Bohr → end) **Module 3** → 6 Q (all) **Module 4** → 5 Q (p1–14: Lewis + resonance only) · Fill in your TEST VERSION # on the bubble sheet

✓ GIVEN ON THE DATA SHEET

Full periodic table (molar masses + Z) · $R_H=2.179\times10^{-18}$ J · $h=6.626\times10^{-34}$ · $c=2.998\times10^{8}$ · N_A · $m_e=9.109\times10^{-31}$ · $e=1.602\times10^{-19}$ · $c=\lambda\nu$ · $E=h\nu$ · $\lambda=h/p$ · $p=mv$ · $KE=\frac{1}{2}mv^2$ · $E_n=-R_H/n^2$ · $\Delta E=-R_H(1/n_f^2-1/n_i^2)$

✎ NOT GIVEN — MEMORIZE

a_0 = 52.9 pm (1s r_mp) · Heisenberg $\Delta x\cdot\Delta p \geq h/4\pi$ · node rules, RDF=$4\pi r^2R^2$ · Aufbau order, all trends · octet / FC / resonance rules

Module 2 · Quantum H Atom

6 Q · §2.4→END

FORMULAS (RYDBERG ETC. ARE GIVEN)

$E_n = -R_H/n^2$ · $\Delta E = -R_H(1/n_f^2 - 1/n_i^2)$
$\lambda = hc/|\Delta E|$ · $\lambda_{dB} = h/(mv)$
Heisenberg (memorize): $\Delta x\cdot\Delta p \geq h/4\pi$

NODE / ORBITAL RULES — KNOW COLD

Quantity	Rule
# orbitals in level n	n^2
# orbitals in subshell	$2\ell+1$
angular nodes	ℓ
radial nodes	$n-\ell-1$
total nodes	n−1
# maxima (R^2, RDF)	$n-\ell$

RDF = $4\pi r^2\cdot R(r)^2$; peak = r_mp. **1s of H: r_mp = a_0 = 52.9 pm** (memorize).

BOHR MODEL (§2.4)

n=1 ground; E negative (0 at n=∞); as n↑ levels **get closer together**. Electron **drops → emits** (ΔE<0), **jumps → absorbs** (ΔE>0). mvr = nh/2π.

DE BROGLIE / HEISENBERG

Matter has wave nature ($\lambda_{dB}=h/mv$); only matters for tiny masses. Can't know position+momentum together → **no exact electron path**.

QUANTUM NUMBERS & ORBITALS

n size · **ℓ** shape (0s,1p,2d,3f) · **m_l** orientation ($-\ell\ldots+\ell$) · **m_s** ±½. For H, energy on **n only** (3s=3p=3d). Orbital = Ψ whose $|\Psi|^2$ = probability.

Shapes: **s** sphere (0 ang nodes) · **p** dumbbell (1 nodal plane) · **d** cloverleaf. **+/− on lobes = PHASE of Ψ, not charge.**

Plot reading: R-vs-r starts at max@r=0 → s; at 0 → p/d/f. Axis crossings = radial nodes → use n−ℓ−1 to get n.

Traps: angular=ℓ, radial=n−ℓ−1 (don't swap). a_0 & Heisenberg NOT on data sheet. **Not tested:** "Are You Wondering" p11, "Digging Deeper" p21 & p31.

Module 3 · Multielectron + Periodic

6 Q · ALL

THE SHIFT FROM H

Multielectron: same-shell orbitals **SPLIT s<p<d<f** (repulsion/shielding). Energy on n and ℓ. ↑Z → orbital contracts (E↓, size↓).

RULES & COUNTS

subshell max e^-: s2 p6 d10 f14 · **shell max = $2n^2$** (2,8,18,32).

Pauli: no 2 e^- share 4 QN → 2/orbital opposite spin. **Aufbau:** lowest n+ℓ first (tie→lower n). **Hund:** singly fill degenerate, parallel, before pairing.

`Fill: 1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s…`

EXCEPTIONS (Z≤36)

Cr=[Ar]$4s^1 3d^5$ · Cu=[Ar]$4s^1 3d^{10}$ (not "half-full stability" myth)

IONS — #1 TRAP

Build neutral, then **remove highest-n FIRST**. d-block: strip **ns before (n−1)d**.

Mn^{2+}=[Ar]$3d^5$ · Fe^{3+}=[Ar]$3d^5$ · Br^+=[Ar]$4s^2 3d^{10} 4p^4$

Valence e^-: grp≤12 = group#; grp≥13 = group#−10.

PERIODIC TRENDS

Property	→ period	↓ group
Atomic radius	↓	↑
Ionization energy	↑*	↓
e^- affinity (mag)	↑	↓
Electronegativity	↑	↓

IE/EA/EN → **top-right** (F=4.0); radius → bottom-left.

Two IE dips (explain by config): Be→B (removes higher-E 2p) · N→O (O's **paired** 2p easier; N's half-filled 2p extra-stable).
EA exceptions (≈0/+): grp 2, grp 18, **N**. Diamagnetic=all paired; paramagnetic=≥1 unpaired.

Module 4 · Bonding (p1–14 ONLY)

5 Q

On Test 2: octet · Lewis structures · formal charge · resonance. That's it.

OCTET & BOND TYPE

Atoms gain/lose/share → noble-gas config (ns^2np^6). Ionic = metal+nonmetal (transfer). Covalent = 2 nonmetals (share).

LEWIS STRUCTURES

Total valence e^- = Σvalence − charge (**add** for anion).

Steps: single-bond skeleton → fill terminal octets → central → make double/triple to complete C/N/O/F octets.

H=1 bond terminal · **C/N/O/F** never exceed octet · **period 3+** may expand (S,P,Cl,Br,I,Xe) · central = least-EN.

Neutral patterns: B 3bd/0lp · C 4/0 · N 3/1 · O 2/2 · F 1/3 · term. O^- 1/3.

FORMAL CHARGE

`FC = valence − (lone-pair e⁻ + ½ bonding e⁻)`

ΣFC = overall charge. Best structure: **smallest FC**; negative FC on **more-EN** atom; avoid like charges adjacent.

e.g. nitrate N: 5 − (0 + 4) = **+1**; terminal −O: 6 − 7 = −1.

RESONANCE

Same skeleton, move **only π electrons & lone pairs** (never break σ). Needs ≥1 double/triple bond. Real molecule = hybrid average → identical bonds.

Equivalent (same FC pattern) → equal; non-equivalent → major/minor.

Trap: when FC magnitudes tie, pick major by **electronegativity** (−charge on more-EN atom), NOT "smaller FC." e.g. OCN^- major = −1 on O.

★ Background · Module 2 §2.1–2.3

light & quantization

NATURE OF LIGHT

Light = EM radiation (oscillating E & B fields). **$c = \lambda\nu$** & **$E = h\nu = hc/\lambda$** (both given). **↑ν → ↑E → ↓λ** (λ and ν inversely proportional).

EM SPECTRUM (KNOW THE ORDER)

radio → microwave → IR → **visible (400–750 nm)** → UV → X-ray → γ. Going right: λ↓, ν↑, energy↑. Violet ~400 → red ~700.

THE 3 EXPERIMENTS (WHAT EACH PROVED)

Experiment	Key idea
Blackbody (Planck)	oscillator energy quantized: E = n·hν (packets)
Photoelectric (Einstein)	light = photons E = hν; ejects e^- only above a threshold **frequency** (not intensity)
Line spectra	atoms emit discrete lines → electron energies are **quantized**

Photoelectric eqn (assemble from data sheet): **$h\nu = w + \frac{1}{2}m_e v^2$** (w = work function). Brighter light = more electrons, not faster. These set up the Bohr model (§2.4).

Periodic Table & Lewis Basics

bridge to M3 & M4

READING THE TABLE (IT'S GIVEN)

Groups = columns 1–18 · **periods** = rows · blocks **s, p, d, f** · metals left/centre, nonmetals upper-right (staircase). Atomic # = protons = electrons (neutral atom).

VALENCE ELECTRONS & LEWIS SYMBOLS

Valence e^- = group # (grp 1–2) or **group # – 10** (grp 13–18). A **Lewis symbol** = element + its valence e^- as dots. This is how you get the electron count for a Lewis structure.

ELECTRONEGATIVITY (NEEDED FOR FC & RESONANCE)

Pull on shared e^-; increases toward **top-right**. Most EN: **F > O > N ≈ Cl** (F = 4.0). Put negative formal charge on the more electronegative atom.

Module 1 · Foundation for M4

ionic vs covalent

Not directly tested — but you need these to draw Lewis structures.

IONIC VS MOLECULAR

Ionic = metal + nonmetal (criss-cross charges to net 0). **Molecular** = two+ nonmetals (covalent).

POLYATOMIC IONS (KNOW THESE)

NH_4^+ ammonium · OH^- hydroxide · NO_3^- nitrate · NO_2^- nitrite · CO_3^{2-} carbonate · HCO_3^- bicarbonate · SO_4^{2-} sulfate · PO_4^{3-} phosphate · CN^- cyanide · $C_2H_3O_2^-$ acetate · MnO_4^- permanganate · ClO_4^-/ClO_3^-/ClO_2^-/ClO^- (per-ate-ite-hypo).

EXAM MATH

Work in scientific notation, keep full precision, round at the end. Unit conversions (nm, pm) are on the data sheet. Watch negative exponents (visible $\lambda \approx 10^{-7}$ m).

NOT on Test 2 — don't study these: Module 1 stoichiometry / limiting reagent / green chem / solubility · Module 4 after p14 (**VSEPR, molecular shapes, polarity, lattice energy, bond strength, line structures**) · **all of Module 5** (VB/MO, hybridization, bond order). These are for the final, not Wed.