NECESSARY PREP

ANKI

16/40 IN THIS TEST CAN BE COMPLETED BY KNOWING GENERAL FACTS.

- ☐ 10+ MIN. DAILY
  - ≥ 5 d/wk
- ☐ MATURED "PERIODICITY" DECK
  - THIS ACTION PRACTICALLY GUARAN 7/40 PTS IN THIS TEST
- ☐ MATURED "VSEPR" DECK
  - PREPARES FOR ALL (4/40)
    - e⁻ DOMAIN GEOM.,
    - molecular GEOM.,
    - bond angles
- ☐ STARTER "ORG FG" DECK
  - 3/40
- ☐ MATURED ~400 CARDS FROM "VOCAB"
  - 2/40 (DIRECTLY)

BETWEEN DEC 4 & NOW, ON AVERAGE I PRACTICED ___ HR/WK, WITH ___ WEEKS OFF. RECOMM.: 3.5 MAX 3!

REGULAR PRACTICE

REMAINDER 24/40 REQ. PRACTICE, OF WHICH 20/40 WOULD HAVE BEEN SEEN FROM:

- ☐ TEXTBOOK CHAPTER Q's
  - ☐ 2
  - ☐ 3
  - ☐ 4.1, 4.2, 4.3
  - ☐ 5.1, 5.2
- ☐ PAST PAPERS BY TOPIC
  - ☐ 2/12 (3)
  - ☐ 3 (3)
  - ☐ 4 (4)
  - ☐ 5 (2)

PAST TESTS

THE LAST 10% (4/40) REQ. YOU TO INTEGRATE ALL YOU HAVE PREV. PRACTICED. PAST TESTS WOULD HELP HERE. (SO, DO FOR LAST WEEKS PRACTICE)

☐ ☐ ☐ ∵ OF DIFFERENT TOPIC COVERAGE FROM YR. TO YR, WILL PROB. WANT TO DO 2–3.

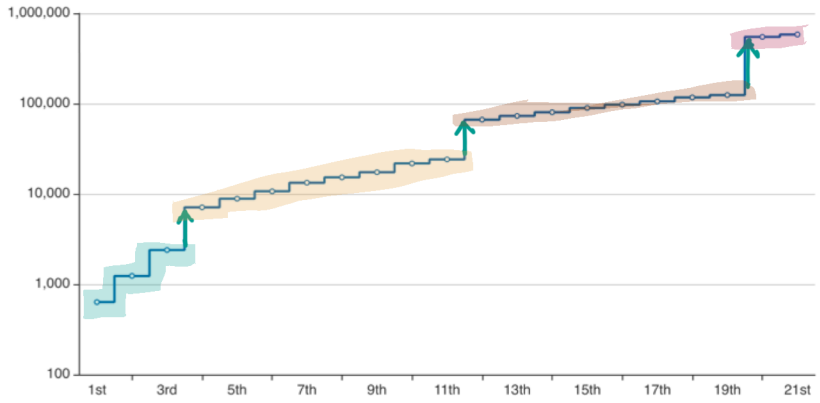
Test: Term 2 Test 2 (2019)

ANSWER KEY

Name and chemistry block: _____

There is a total of 40 points, and is to be completed within 60 min. Calculators and Data Booklets are allowed.

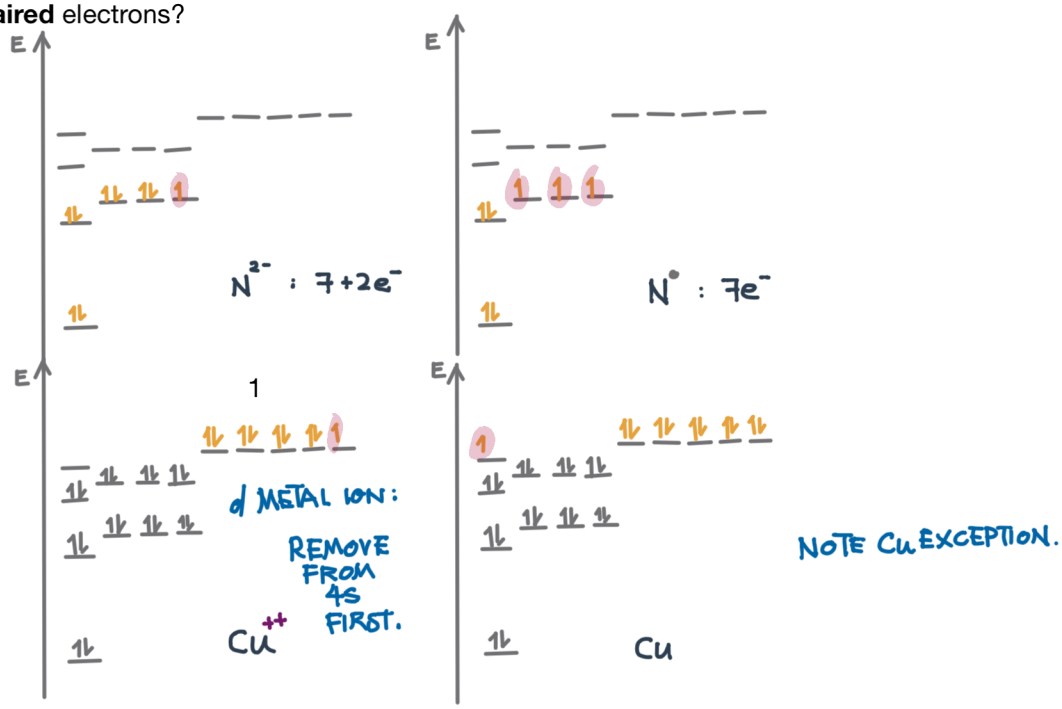
[1] 1. Which element gives the following successive ionization energy graph?



A. ~~B~~ DOES NOT HAVE 21 e⁻
B. ~~Al~~
C. Sc — EASY $3d^1 4s^2$ → $3p^6 3s^2$ → $2p^6 2s^2$ → $1s^2$ HARD
D. ~~Ga~~ HAS ALSO 3d e⁻

[1] 2. Which has the most **unpaired** electrons?

A. N^{2-}
B. N
C. Cu^{2+}
D. Cu



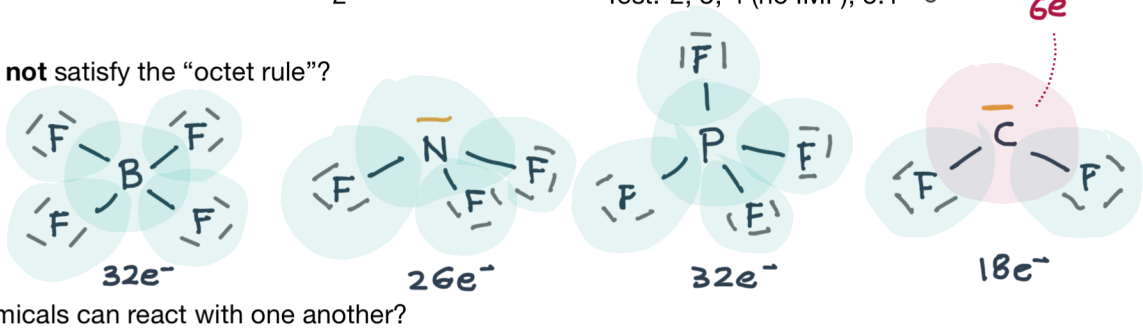
[1] 3. Which species **do not** satisfy the "octet rule"?

OCTET A. BF_4^-

OCTET B. NF_3

OCTET C. PF_4^+

D. CF_2



[1] 4. Which pair of chemicals can react with one another?

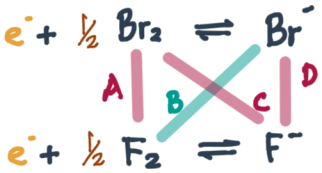
A. $F_2 + Br_2$

B. $F_2 + NaBr$

C. $NaF + Br_2$

D. $NaF + NaBr$

USING "THE TRICK":



[1] 5. Which molecule has a V-shaped/bent molecular geometry?

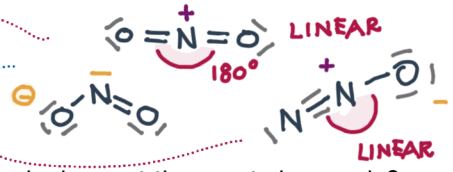
A. NO

B. NO_2^+

C. NO_2^-

D. N_2O

TWO ATOMS: CANNOT BE BENT!



[1] 6. Which pair of chemicals react the most vigorously?

A. $Li_{(s)} + LiCl_{(s)}$

B. $Na_{(s)} + NaCl_{(s)}$

C. $Li_{(s)} + HCl_{(aq)}$

D. $Na_{(s)} + HCl_{(aq)}$

NO REACTION

∵ ↑ SIZE ⇒ ↓ ATTR $p^+ - e^-$ ∴ ↑ REACTIVITY

[1] 7. An alloy is

A. A homogenous mixture of two or more metals.

B. A heterogenous mixture of two or more metals.

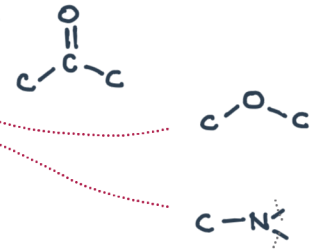
STAINLESS STEEL: Fe + CARBON

C. A homogenous mixture of a metal with other metals or non-metals.

D. A heterogenous mixture of a metal with other metals or non-metals.

[1] 8. Which functional groups contain a C=O bond?

I Ketone
II Ether
III Amine



A. I only
B. I & II
C. I & III
D. I, II, and III

9. The hydrogen absorption spectra in the **visible** range is shown in Figure 1.

Figure 1 Hydrogen absorption spectra in visible range.

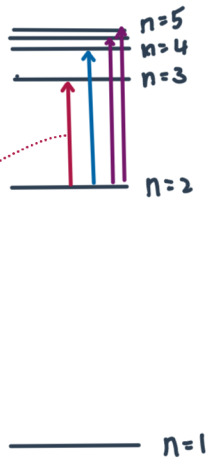
[1] (a) Which is a suitable label for the axis?

A. E ($\frac{kJ}{mol}$)
B. λ (nm)
C. ν (Hz)
D. f (s^{-1})

[1] (b) The line labeled with * represents the transition:

A. n=2 → n=4
B. n=2 → n=3 LOWEST ENERGY LINE
C. n=1 → n=3
D. n=1 → n=2

∵ LARGE TRANSITION
∴ UV, NOT VISIBLE



10. The half-life of ^{63}Ni is 100 years.

[1] (a) How many neutrons is in an atom of ^{63}Ni?

(a) 35

$\because Z = 28 \quad \therefore p^+ = 28$

$p^+ + n^\circ = 63 \quad \Leftrightarrow \quad n^\circ = 63 - 28 = 35$

[1] (b) Starting with 1,000,000 atoms of ^{63}Ni in 2020, estimate the number remaining in 3020.

(b) 1000

TIME ELAPSED = 3020 − 2020 = 1000 YRS

HALF LIVES = TIME / $t_{1/2}$ = 1000 / 100 = 10

REMAIN = % REMAIN × TOTAL

$= \left(\frac{1}{2}\right)^{10} \times 1000000$ ATOMS

$= \frac{1}{1024} \times 1000000$ ATOMS

$\cong 1000$ ATOMS

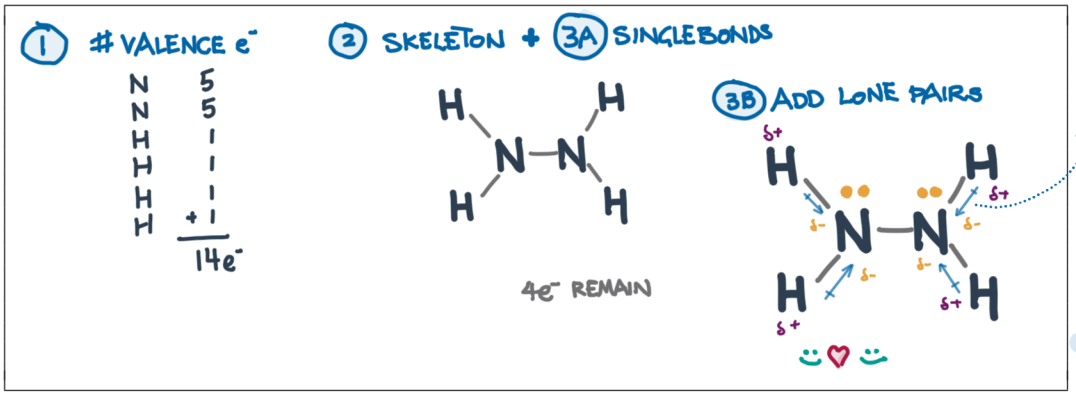
MARKING

✓	CORRECT, USUALLY [1]
• / OK	PART OF A CORRECT ANSWER
✓x	PARTIALLY CORRECT
BOD	BENEFIT OF DOUBT — AN AMBIGUOUS ANSWER INTERPRETED IN YOUR FAVOR
ECF	ERROR CARRIED FORWARD — ERROR MADE IN PREV. PART PROPAGATED ALONG.
0 / x	INCORRECT
\ / NR	NO RESPONSE

11. Hydrazine N_2H_4 is a highly toxic, dangerously unstable compound used in some rocket fuels.

[2] (a) i. Draw a Lewis structure for hydrazine $N_2H_{4(l)}$. Annotate the diagram with bond dipoles.

[1] LEWIS STRUCTURE
[0] IF LONE PAIRS NOT SHOWN
[1] BOND DIPOLES

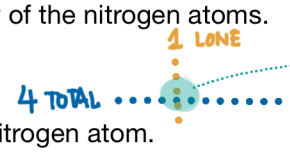


• MARKS FOR NEXT PARTS AWARDED BASED ON ABOVE LEWIS STRUCTURE.

[1] ii. *α*) Identify the **electron domain geometry** of the nitrogen atoms.

∵ 4 e⁻ DOMAINS ∴ *α*) TETRAHEDRAL

[1] *β*) Identify the **molecular geometry** of the nitrogen atoms.



β) TRIGONAL PYRAMIDAL
• CORRECT SPELLING REQ'D.

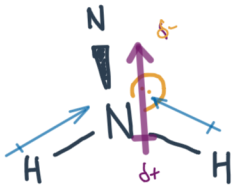
[1] iii. Estimate[1] the bond angle around a nitrogen atom.

iii. 107°
• ACCEPT 105° – 109°
• DO NOT ACCEPT 109.5° OR < 109.5°

[1] iv. Explain whether hydrazine is expected to be a polar molecule.

[1] BOTH
• BONDS POLAR AND
• LACK OF SYMM.

YES, ∵ DIPOLES FROM POLAR N–H BONDS DO NOT FULLY CANCEL OUT.



[1] Give an educated guess of a single value. Do **not** give a range like < 360°

(b) Hydrazine decomposes to give nitrogen gas $N_{2(g)}$ and hydrogen gas $H_{2(g)}$ via the reaction

$$N_2H_{4(l)} \longrightarrow N_{2(g)} + 2H_{2(g)}$$

The enthalpy of reaction ΔH°_{rxn} is -50.6 kJ/mol.

At SATP, 100.0 g of hydrazine is decomposed in a calorimeter surrounded by 500.0 cm^3 chamber filled with water.

[2] i. Calculate the number of moles in 100.0 g of hydrazine.

i. 3.12₀ mol

$M_{N_2H_4} = 2A_N + 4A_H = 32.05$ g/mol

$n = \frac{m}{M} = \frac{100.0}{32.5}$ g / g/mol $= 3.12_0$ mol

[1] ii. Calculate the heat released when 100.0 g of hydrazine decomposes. (If you were unable to completed the last question[2] you may use a value of 5.00 mol although this is not the correct answer.)

ii. -157.₉ kJ

$q_{rxn} = \Delta H \times n$

$= -50.6$ kJ/mol $\times$ 3.12₀ mol

$= -157.9$ kJ

[2] iii. Deduce the temperature of the water after the hydrazine completely decomposes. (If you were unable to complete the last question, you may use a value of 1.00×10^2 kJ although that is not the correct answer.)

iii. 373.₆ K

∵ CONSERVATION OF ENERGY,

$q_{released, NaH_4^+} + q_{abs, H_2O} = 0$

$m_{H_2O} c_{H_2O} \Delta T = -q_{released}$

5000 g × 4.18 J/g·K × ΔT = −157900 J

$\Delta T = 75.6$ K

SATP

$T_{FINAL} = T_{INIT} + \Delta T$

$= 298$ K + 75.6 K

$= 373.6$ K

[2] In other words, if you completed the last question, use that value.

[1] iv. State **one** assumption in the previous calculation, other than "no heat loss to surroundings".

NOTE: FINAL T = 100.5°C!

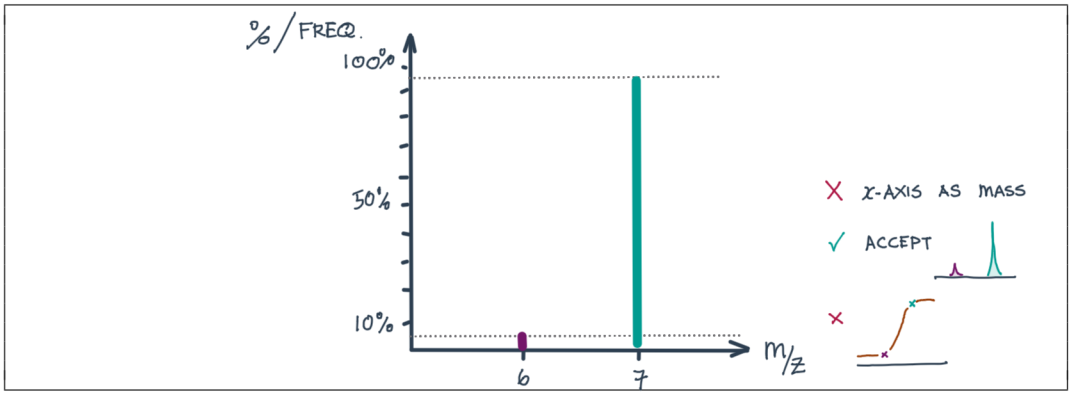
iv. _____

- NO WATER WAS EVAPORATED / NO ENERGY LOST TO BOILING
- SPECIFIC HEAT CAPACITY OF WATER CONSTANT
- GASEOUS PRODUCTS (N_2, H_2) DOES NOT ABSORB HEAT

12. Lithium is a flammable metal, with important applications in glass, steel production, and in lithium-ion batteries.

(a) Lithium exists as two stable isotopes, ^{6}Li (5%) and ^{7}Li (95% abundance).

[1] i. Sketch a mass spectra for naturally occurring lithium. Label both axes.



[1] ii. Calculate the relative atomic mass of lithium.

WEIGHED CONTRIBUTION FROM ^{6}Li

WEIGHED CONTRIBUTION FROM ^{7}Li

ii. 6.95

- NO UNITS FOR RELATIVE MASS, BUT AWARD [1] EVEN IF g/mol WAS GIVEN.

$M_{r\,Li} = (0.05 \times 6) + (0.95 \times 7)$

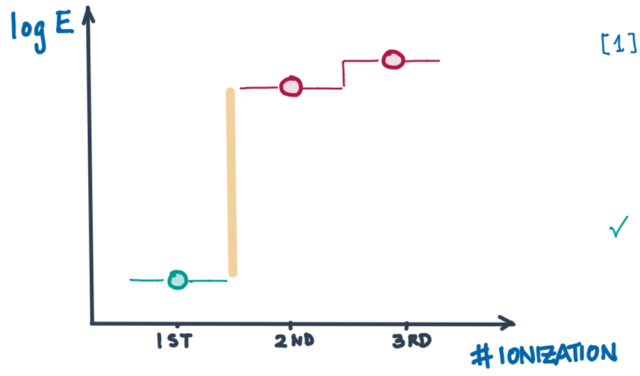
$= 6.95$

[1] (b) Formulate an equation for the **second** ionization energy of lithium.

$Li^{+}_{(g)} \longrightarrow Li^{++}_{(g)} + e^{-}$

[0] IF (g) IS OMITTED.

[1] (c) Sketch a graph for the successive ionization energies of lithium. Use a logarithmic scale for energy. Label the axes.



[1] FOR ALL OF
- MONOTONIC INCREASE
- JUMP BTW 1ST & 2ND
- LABELED AXES

✓ ACCEPT CONTINUOUS NOTATION & POINTS ONLY NOT½.

[2] (d) Explain, giving **two** reasons, why lithium has lower density (0.534 g/cm^3) than beryllium (1.85 g/cm^3).

[1]@

THIS IS REALLY A METALLIC BONDING QUESTION.

- Li HAS LOWER ATOMIC MASS
- Li HAS LARGER IONIC RADII
- Li METAL HAS 1 DELOCALIZED e⁻ / Be METAL HAS 2 DELOCALIZED e⁻s } ∴ STRONGER ATTRⁿ IN LATTICE FOR Be

[2] (e) Explain, using a chemical equation, why water-based fire extinguishers **cannot** be used to put out a lithium fire.

[1] $2\,Li^{0}_{(s)} + 2\,H_2O_{(l)} \longrightarrow H_2\uparrow + 2\,LiOH_{(aq)}$

LITHIUM REACTS WITH WATER TO GIVE FLAMMABLE H_2 GAS IN AN EXOTHERMIC RXN.

[1] FOR EITHER REASON

[0] FOR RE-STATING Li RXTS o/ H_2O

13. Aspirin and ibuprofen are medications used to treat pain and inflammation. Aspirin's 3D structure is shown in Figure 2.

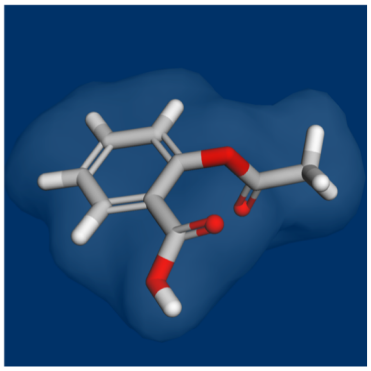
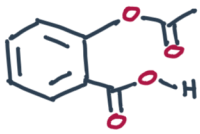


Figure 2 3D structure of aspirin.

[1] (a) Draw a **skeletal** (simplified) structural formula of aspirin.



✓ ACCEPT DELOCALIZED RING
✓ ACCEPT ALT. KEKULÉ STR.
✓ ACCEPT –COOH
✓ ACCEPT EXPLICIT $-CH_3$
✗ DO NOT ACCEPT ALL ATOMS EXPLICIT

[2] (b) State **two** functional groups present in aspirin. Do not include "alkane" as one of your answers.

[1] EACH

ARENE, ESTER, CARBOXYLIC ACID

✓ ACCEPT PHENYL AND CARBOXYL
[-1] FOR EACH INCORRECT RESPONSE

[1] (c) Figure 3 shows the 3D structure and skeletal structure of ibuprofen.

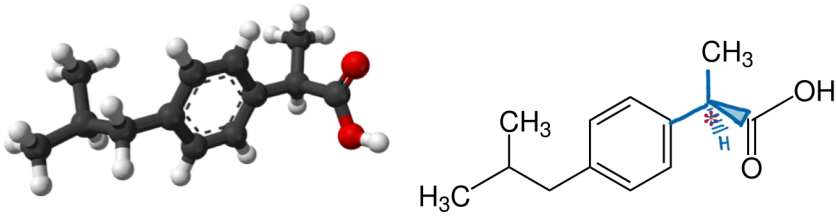


Figure 3 Structures of ibuprofen.

✓ AWARD [1] EVEN IF H IS MISSING
✓ ACCEPT
✗ DO NOT ACCEPT OR

Using appropriate bonds to represent the 3D shape, complete the structure at the starred * carbon.

14. Figure 4 shows the first ionization energy and electron affinity for the element sodium to potassium.

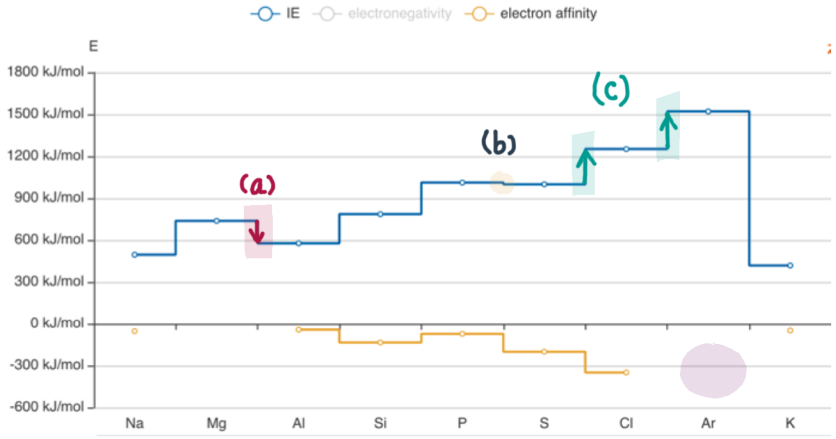


Figure 4 Periodic trends

AWARD MAX [2] FOR (a→d) IF ALL e⁻ CONFIGURATIONS MISSING OR INCORRECT

By referring to their electron configurations, explain:

[1] (a) Why I.E. decreases from Mg to Al.

Mg : [Ne] $3s^2$
Al : [Ne] $3s^2 3p^1$
} I.E. FOR Al REMOVES FROM 3p ORBITAL INSTEAD OF LOWER E, MORE STABLE 3s ORBITAL AS c/ Mg.

[1] (b) Why I.E. decreases from P to S.

P : [Ne] $3s^2 3p_x^1 3p_y^1 3p_z^1$
S : [Ne] $3s^2 3p_x^1 3p_y^1 3p_z^2$
} e^- REMOVED FOR S SUBJECTED TO ADDITION $e^- - e^-$ REPULSION IN SAME ORBITAL.

[1] (c) Why I.E. increases from S to Ar.

S : [Ne] $3s^2 3p^4$
Ar : [Ne] $3s^2 3p^6$
} ALL e^- REMOVED FROM 3p ORBITAL (c/ $e^- - e^-$ REPULSION) BUT ↑Z ⇒ ↑p^+ ⇒ ↑ATTR^N $p^+ - e^-$ ⇒ ↑E req'd to remove e^-

[1] (d) Why no E.A. is available for Ar.

Ar : [Ne] $3s^2 3p^6$
THE NEXT e^- GAINED NEEDS TO GO INTO A ↑E 4s ORBITAL.
THIS IS ENERGETICALLY UNFAVORABLE & DOES NOT HAPPEN NORMALLY.

AWARD [0] FOR COMMENTING Ar AS "INERT / UNREACTIVE NOBLE GAS."

IT IS POSSIBLE TO FORCE THIS IN SPECIAL CIRCUMSTANCES: $E.A._{Ar}$ HAS BEEN MEASURED TO BE +96 kJ/mol.