ANSWER KEY.

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2.4 Structure of Metals and Alloys

AP Chemistry | ANSWER KEY

Explain each answer at the particle level. Use Coulomb's law and the sea of electrons model.

1. Lithium melts at 181 °C and potassium melts at 64 °C.

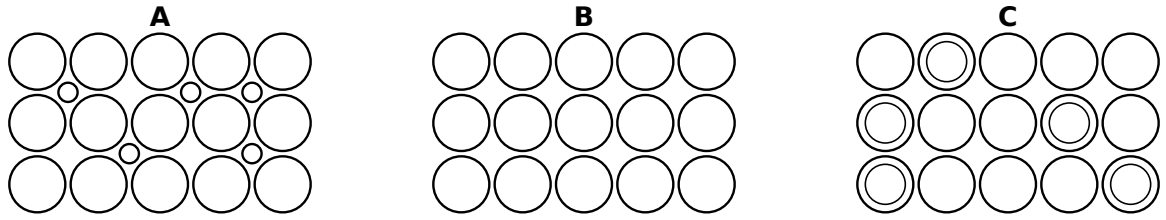
(a) Explain this difference using metallic bonding.

(b) Predict which metal has the higher melting point, sodium or aluminum. Justify your prediction.

(a) Both form 1+ ions and give 1 electron to the sea, but Li's valence electron is in n = 2 and K's is in n = 4, so Li^+ is much smaller than K^+. A smaller cation is closer to the electron sea, so the attraction is stronger and more energy is needed to melt lithium.

(b) Aluminum. Al^{3+} gives 3 electrons per atom to the sea and is smaller than Na^+, so its metallic bonding is stronger. (Actual: Al 660 °C, Na 98 °C)

2. Identify each diagram as a pure metal, an interstitial alloy, or a substitutional alloy. Justify one of your choices.



A: interstitial alloy (small atoms sit in the holes between larger atoms). B: pure metal (one kind of atom). C: substitutional alloy (atoms of similar size, shown with an inner ring, replace host atoms in lattice positions).

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3. Use the atomic radii to classify each alloy as interstitial or substitutional.

Atom	Fe	N	Cu	Sn	Au	Ag
Radius (pm)	126	75	128	140	144	144

(a) nitrogen in iron (b) bronze, tin in copper (c) gold mixed with silver

(a) interstitial: N (75 pm) is much smaller than Fe (126 pm) and fits in the holes.

(b) substitutional: Sn (140 pm) and Cu (128 pm) are similar in size. (c) substitutional: Au and Ag are the same size (144 pm).

4. Steel is iron with a small amount of carbon added. Compared with pure iron, is steel more or less (a) malleable, (b) dense, and (c) hard? Explain using the structure of the alloy.

(a) less malleable (b) more dense (the model: carbon adds mass without adding volume) (c) harder

The small carbon atoms fill holes between the iron atoms. They add mass without adding volume, and they act like wedges that keep the layers of iron atoms from sliding past each other.

5. Solid aluminum conducts electricity. Solid Al_2O_3 does not, but molten Al_2O_3 does. Explain all three observations.

Conduction needs charged particles that can move. Solid Al has delocalized valence electrons that flow through the metal.

In solid Al_2O_3, the Al^{3+} and O^{2-} ions are locked in the lattice and there are no free electrons. When melted, the ions can move, so it conducts.

6. Gold can be hammered into sheets thinner than paper, but a crystal of NaCl shatters when hit with a hammer. Explain the difference at the particle level.

In gold, layers of cations slide past each other while the sea of electrons keeps attracting them. The bonding is nondirectional, so the metal bends.

In NaCl, shifting a layer lines up like charges. They repel, so the crystal breaks.

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