CH 8 21 - 28

21. a) Lattice Energy is usually exothermic.
When particles naturally attract it usually results in a release of energy and greater Stability.

b) $Na^+_{(g)} + Cl^-_{(g)} \rightarrow NaCl_{(s)}$
↑ gaseous ↑

* This depends on how you define lattice energy!!

c) Use Coulombs law to explain/justify!

Singly-charged ions would have Smaller lattice energy compared to doubly-charged ions.

$$F = k\frac{Q_1 Q_2}{r^2}$$

Force of attraction between the 2 ions.
↓
Also a measure of Lattice Energy.

The more attracted the ions are to each other, the more energy is released.

$$\frac{(+1)(-1)}{r} \qquad \frac{(+2)(-2)}{r}$$

$$\left(\frac{-1}{r}\right) \text{ compare to } \left(\frac{-4}{r}\right)$$

↓
Force of attraction is 4x greater than in singly-charged ions.

The main factor is the charges because the radii of ions do not vary over a wide range.

22. a) NaCl LE = 788 KJ/mole
KF LE = 808 KJ/mole

I would expect the NaCl bond to be longer than the KF bond length. LE is the energy released when an ionic bond forms. It would also be the amount of Energy needed to break the bond.

* Long bonds are usually weaker than short bonds.

b) Na^+ 1.16 A
Cl^- 1.67 A
K^+ 1.52 A
F^- 1.19 A

Na – Cl ~ 2.83 A
K – F ~ 2.71 A

agrees

23. a) Na^+ Ca^{2+}

b) F^- O^{2-}

c) CaO has largest LE according to <u>Coulomb's Law</u>:

CaO: $\frac{(+2)(-2)}{r}$ (3414 KJ/mole)

NaF: $\frac{(+1)(-1)}{r}$ (910 KJ/mole)

r is ~ same for both because all 4 ions have same electron configuration $1s^2 2s^2 2p^6$

d) ScN (7547 KJ/mol)

Sc^{3+} N^{3-} → $1s^2 2s^2 2p^6$

$\frac{(+3)(-3)}{r} = \frac{-9}{r}$ → Predict ~ 6X greater than NaF

$910 \times 9 = 8190$ KJ/mol → slightly larger than actual LE of 7547. Our estimate does not take r into account.

24. a) i) As charges of ions increases, LE increases

ii) As sizes of ions increases, LE decreases

$E = \frac{(Q_1)(Q_2)}{r}$ coulombs Law

b) MgS: $\frac{(+2)(-2)}{r}$ → $\frac{-4}{r}$ → 2nd highest L.E.

GaN: $\frac{(+3)(-3)}{r}$ → $\frac{-9}{r}$ → highest LE

KI: $\frac{(+1)(-1)}{r}$ LiBr: $\frac{(+1)(-1)}{r}$

Both $\frac{-1}{r}$ ← LE now depends on ionic radius

K^+ 4EL, I^- 5EL → longest r

Li^+ → 1 EL, Br^- → 4EL → shortest r

GaN > MgS > LiBr > KI

Coulomb's Law

25. a) KF NaCl NaBr LiCl

(KF: 3EL, 2EL → 5; NaCl: 2EL, 3EL → 5; NaBr: 2EL, 4EL → 6; LiCl: 1EL, 3EL → 3)

b) $\frac{(+)(-)}{r}$ $\frac{(+)(-)}{r}$ $\frac{(+)(-)}{r}$ → longest bond $\frac{(+)(-)}{r}$ → shortest bond

LiCl > ? > ? > NaBr

If NO Ionic Radii information

Using the Table:

a) K−F 1.52A + 1.19A = 2.71A

Na−Cl 1.16A + 1.67A = 2.83A

Na−Br 1.16A + 1.82A = 2.98A

Li−Cl 0.90A + 1.67A = 2.57A

Coulomb's Law

b) LiCl > KF > NaCl > NaBr

26. choice a. is due differences in ionic radii

$NaCl$ (2EL, 3EL) > $RbBr$ (4EL, 4EL) > $CsBr_2$ (5EL, 4EL)

$\frac{(+)(-)}{r}$ → r = 5EL; $\frac{(+)(-)}{r}$ → r = 8EL; $\frac{(+)(-)}{r}$ → r = 9EL

choice b. is due to charge

BaO (5EL, 2EL) > KF (3EL, 2EL)

$\frac{(+2)(-2)}{r}$ → r = 7EL; $\frac{(+)(-)}{r}$ → r = 5EL

$\frac{-4}{7}$ $\frac{-1}{5}$

Coulomb's Law

choice c. is due to charge

SrO (4EL, 2EL) > $SrCl_2$ (4EL, 3EL)

$\frac{(+2)(-2)}{r}$ $\frac{(+2)(-1)}{r}$

$\frac{-4}{6}$ $\frac{-3}{7}$

27. a. The lattice energy (exothermic) of CaO is large enough to overcome the 2 endothermic processes.

28. 1. Sublimation of the $Ba_{(s)}$ → endothermic (ΔH sub)
$Ba_{(s)} \rightarrow Ba_{(g)}$

2. Ionization of the $Ba_{(g)}$ to $Ba^{2+}_{(g)}$
(1st IE) → endothermic $Ba_{(g)} \rightarrow Ba^{+}_{(g)} + e^-$
(2nd IE) → endothermic $Ba^{+}_{(g)} \rightarrow Ba^{2+}_{(g)} + e^-$

3. Separation of I_2 molecules into I atoms → endothermic
? $I_{2(s)} \rightarrow 2I_{(g)}$ $I_{2(s)} \rightarrow I_{2(g)}$ (endo) → (ΔHsub)
$I_{2(g)} \rightarrow 2I_{(g)}$ (endo) → (Bond energy)

4. Ionization
$2I_{(g)} + 2e^- \rightarrow 2I^-_{(g)}$ (1st electron affinity × 2) exothermic

5. $Ba^{2+}_{(g)} + 2I^-_{(g)} \rightarrow BaI_{2(s)}$ exothermic (lattice energy)