The binding energy per nucleon for magnesium-27 is 1.326 x 10⁻¹² J/nucleon. Calculate the atomic mass in g/mol of magnesium-27.

mass of proton = 1.0073 g/mol   mass of neutron = 1.0087 g/mol   mass of electron = 5.4859 x 10^{-4} g/mol

light speed = 2.9979 x 10^{8} m/s

(1)

magnesium-27
12 p^+
15 n
12 e^-

binding energy only relates to the nucleus

$-1.326 \times 10^{-12} \frac{J}{nucleon} \times 27 \text{ nucleons} = -3.580_2 \times 10^{-11} J$ ← energy of mass defect (Δm)

$^{27}Mg = \Delta m + 12p^+ + 15n + 12e^-$

$\Delta m = \frac{E}{c^2} = \frac{-3.580_2 \times 10^{-11} J}{(2.9979 \times 10^8 \frac{m}{s})^2} = \frac{-3.580_2 \times 10^{-11} \frac{kg \cdot m^2}{s^2}}{(2.9979 \times 10^8)^2 \frac{m^2}{s^2}} = -3.983_{58} \times 10^{-28} kg$

$= -3.983_{58} \times 10^{-25} g$

$= -0.2398_{91} g/mol$

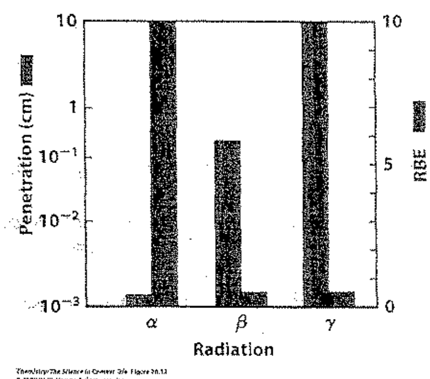
$(12p^+ + 15n) = 12(1.0073 \frac{g}{mol}) + 15(1.0087 g/mol)$

$= 27.2181 g/mol$

$^{27}Mg = (-0.2398_{91} + 27.2181 + 12(5.4859 \times 10^{-4}))\ g/mol = \boxed{26.9847_{92}\ g/mol}$

(2)

Both iodine-129 and phosphorus-32 are classified as highly internally toxic. Rationalize this fact based on the penetration ability, relative biological effectiveness, and your answers to part e in questions 5 and 6.



While it appears that β^- particles are stopped within mm lengths, if these nuclides are ingested the mm scale is huge on the cellular level and exposure at this level is significant.
While the RBE appears small, ingested nuclides still produce highly energetic β^- particles that can deposit large amounts of energy in a small space (i.e. cells)

③

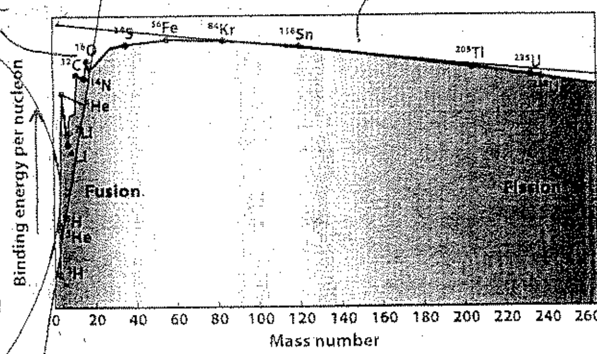
Using the binding energy plot shown below and the fact that <u>fusion</u> occurs for nuclides below $^{56}_{26}\text{Fe}$ and <u>fission</u> occurs for nuclides above $^{56}_{26}\text{Fe}$, *explain why more energy is released in a fusion process versus that in a fission process.*

B

A

Slope of A < Slope of B

Fission Energy < Fusion Energy



Chemistry: The Science in Context 2/e Figure 20.5 © 2006 W. W. Norton & Company, Inc.

More energy per nucleon released means that the resulting nuclide is more stable. Looking at the plot, building nuclides up to ^{56}Fe releases ever more energy. After fusion has produced ^{56}Fe additional fusion can produce unstable nuclides that undergo fission to achieve stability.

(4)

______ **Creatinine, $C_4H_7N_3O$, is a by-product of muscle metabolism, and creatinine levels are known to be a fairly reliable indicator of kidney function.**

The normal creatinine concentration in blood is 1.0 mg per deciliter of blood.
The density of blood is 1.025 g/mL at 25.0 °C.

deci = 10^{-1} *R = 0.0821 L•atm/mol•K* *report values with the proper number of significant figures*

a) Calculate the molality (m) of a normal creatinine level in a 10.0 mL blood sample.
b) Calculate the osmotic pressure of this solution (creatinine in blood) at 25.0 °C.
c) Explain why osmotic pressure spontaneously develops in a system containing creatinine-free blood, a semi-permeable membrane and blood containing creatinine.

c) An area of high concentration spontaneously dilutes in order to maximize entropy. In osmosis an equilibrium is established by flow of blood to balance the [Creatinine] on each side of the membrane

$C_4H_7N_3O$ MM = 113.12_{54} g/mol

a) $m = \frac{\text{moles solute}}{\text{kg solvent}}$

moles solute = $\frac{10.0 \text{ mL blood}}{1} \cdot \frac{1.0 \text{ mg Creat.}}{1 \text{ dL blood}} \cdot \frac{1 \text{ g}}{1000 \text{ mg}} \cdot \frac{1 \text{ mol Creat.}}{113.12_{54} \text{ g Creat.}} \cdot \frac{1 \text{ dL}}{100 \text{ mL}} = 8.8_4 \times 10^{-7}$ mol Creatinine

(3sf, 2sf, ex., 5sf, ex.)

kg solvent = $\frac{1.025 \text{ g}}{1 \text{ mL}} \cdot \frac{10.0 \text{ mL}}{1} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} = 0.0102_5$ kg

(4sf, 3sf, ex)

$m = \frac{8.8_4 \times 10^{-7} \text{ mol}}{0.0102_5 \text{ kg}} = 8.6_2 \times 10^{-5}$ m

b) $\pi = MRT$, $T = 298$ K

$M = \frac{8.8_4 \times 10^{-7} \text{ mol}}{0.0100 \text{ L}} = 8.8_4 \times 10^{-5}$ M

$\pi = (8.8_4 \times 10^{-5} \text{ M})(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(298 \text{ K}) = 0.0021_6 \text{ atm} = 2.1_6 \times 10^{-3} \text{ atm}$
$= 1.6_4$ torr

... dissolved in enough water to

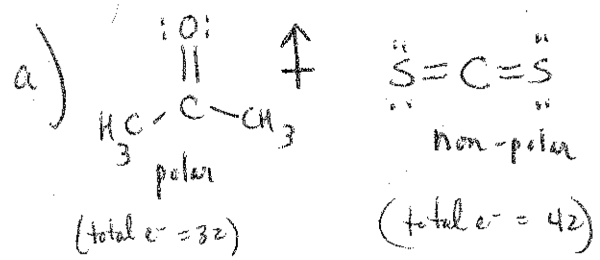
(5) **A solution composed of 0.60 mol acetone, $(CH_3)_2CO$, and 0.40 mol carbon disulfide has a vapor pressure of 615 mmHg at 35.2 C.**

a. This solution is not ideal. Why not? Consider the energy trade-off.

b. Calculate the vapor pressure of the solution assuming ideal behavior; pure acetone's $P°_{vap}$ = 349 mmHg, pure carbon disulfide's $P°_{vap}$ = 501 mmHg.

c. Predict the sign of the heat of solution.

a)



The dominant VDW force for acetone is dipole-dipole (+ dispersion) and that for carbon disulfide is dispersion alone. It likely will require more energy to separate the pure liquids than is released when the liquids mix. The VDW forces in the pure liquids are too dissimilar.

b) $P_{TOTAL} = \chi_A P^\circ_A + \chi_{CD} P^\circ_{CD}$

$P_{TOTAL} = \left(\frac{0.60}{1}\right)(349 \text{ mmHg}) + \left(\frac{0.40}{1}\right)(501 \text{ mmHg})$

$= 409.8 \text{ mmHg} = 4.1 \times 10^2 \text{ mmHg}$

c) $P_{TOTAL\ CALC} < P_{TOTAL\ ACTUAL}$, A positive deviation, $\Delta H^\circ_{soln} > \phi$ endothermic

(6) **Colligative properties have limited use in molar mass determination when the molar mass becomes greater than 20,000 g/mol. Give an explanation of this fact.**

Since colligative properties are based on number of particles rather than there chemical nature, for the same amount (g) of different substances, the greater the MM the fewer the particles. Fewer particles will give a smaller ΔT which usually is less accurate + precise for the thermometers used (± 0.1°C

A less accurate + precise ΔT will lead to an incorrect MM.