Complete the following problems. You must show your work to receive full credit. Show your answers to the correct number of significant figures with the correct units.

1. Of the following substances: C_3H_8, N_2, CH_3OH, and N_2O, one is a liquid at room temperature, whereas the rest are gaseous.   Which compound do you think is the liquid? Clearly explain your reasoning. (12 pts)
Since the molar masses of all of the compounds are very similar, differences in state (boiling point) are likely due to differences in intermolecular forces. You should examine the types of intermolecular forces possible in each compound and try to identify which compound should have the strongest intermolecular forces.

Compound	C_3H_8	N_2	CH_3OH	N_2O
IM Forces	Dispersion	Dispersion	Dispersion, dipole-dipole, H-bonding	Dispersion, dipole-dipole

Since CH_3OH exhibits both dipole-dipole and hydrogen bonding interactions, it is likely that it has the strongest intermolecular forces, and therefore the highest boiling point. As a result, it should be a liquid at a higher temperature than any of the other compounds. Your discussion should justify your choice in comparison to the other compounds.

2. Aluminum crystallizes in a face-centered cubic structure. If the atomic radius of aluminum is 143.1 pm,
a. what is the volume of the unit cell in cm^3? (7 pts)

For a fcc structure, the diagonal of one face consists of four atomic radii. To determine the volume of the unit cell, we need the length of the side. We can get that with this knowledge of the diagonal: $a^2 + a^2 = (4r)^2$, so that $a = ((4 \times 143.1pm)^2/2)^{1/2} = 404.7$ pm

Then the volume is a^3, converted to cm^3

$$\text{Volume} = \left[404.7 \; \cancel{pm} \times \frac{10^{-12} \; \cancel{m}}{1 \; \cancel{pm}} \times \frac{1 \; cm}{10^{-2} \; \cancel{m}} \right]^3 = \mathbf{6.63 \times 10^{-23} \; cm^3}$$

b. what is the density of aluminum in g/cm^3? (1 pm = 10^{-12} m) (6 pts)

For a fcc structure, there are four atoms contained in the unit cell. Therefore:

Then the volume is a^3, converted to cm^3

$$\frac{4 \; \cancel{atoms}}{6.63 \times 10^{-23} \; cm^3} \times \frac{1 \; \cancel{mol}}{6.02 \times 10^{-23} \; \cancel{atoms}} \times \frac{26.9815 \; g}{1 \; \cancel{mol}} = \mathbf{2.70 \; g/cm^3}$$

Bonus (3 pts):

Draw the structure of any compound that contains an amine and a carboxylic acid and has the molecular formula $C_4H_9NO_3$.

Several possible answers exist.

Possibly Useful Information

1 1A	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794																	2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9332	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	89 †Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

*Lanthanide series	58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
†Actinide series	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)