H 2.1	*Pauling* Electronegativity					
Li 1.0	**Be** 1.5	**B** 2.0	**C** 2.5	**N** 3.0	**O** 3.5	**F** 4.0
Na 0.9	**Mg** 1.2	**Al** 1.5	**Si** 1.8	**P** 2.1	**S** 2.5	**Cl** 3.0
K 0.8	**Ca** 1.0	**Ga** 1.6	**Ge** 1.8	**As** 2.0	**Se** 2.4	**Br** 2.8
Rb 0.8	**Sr** 1.0	**In** 1.7	**Sn** 1.8	**Sb** 1.8	**Te** 2.1	**I** 2.5
Cs 0.7	**Ba** 0.9	**Tl** 1.8	**Pb** 1.9	**Pb** 1.9	**Po** 2.0	**At** 2.2

Useful units

Avogadro number $N_A = 6.022 \times 10^{23}$ mol^{-1}

Gas constant (SI) $R = 8.3145$ J mol^{-1} K^{-1}

Gas constant $R = 0.08206$ L atm mol^{-1} K^{-1}

1 atm = 101 325 Pa = 760 mm Hg

1 m^3 = 10^3 L

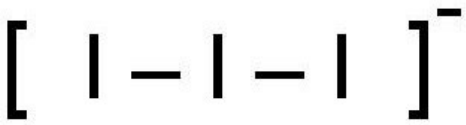
Q1 **Consider the Lewis structure and the VSEPR-geometry of these molecules and decide which molecule has a linear structure.**

a) HCN
b) NH_4^+
c) CO_3^{2-}
d) SeF_2
e) H_2O

Q2 **Complete the Lewis structure of the I_3^--ion and identify the appropriate hybridization of the central I-atom**

a) sp
b) sp^2
c) sp^3
d) dsp^3
e) d^2sp^3
f) none of the above

I_3^- ion:



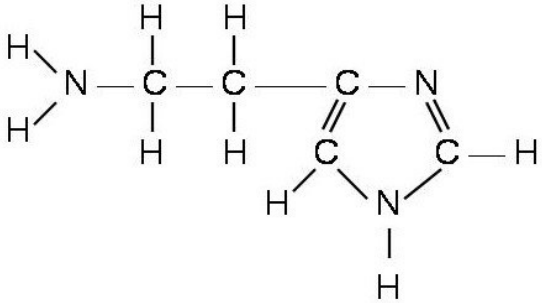
Q3 **For which of these molecules do you predict the smallest bond angle?**

a) CH_4
b) NH_3
c) H_2S
d) CCl_4
e) SiF_4

Q4 **As a response to allergens the body produces histamine. Complete the Lewis structure. How many sp^3 hybridized carbon atoms do you identify in this molecule?**

a) 2
b) 3
c) 4
d) 5
e) none

Histamine:



Q5 **How many σ-bonds do you identify in the Histamine molecule?**

a) 2
b) 15
c) 17
d) 19
e) 22

Q6 **Which of the following gas atoms or molecules has the largest root mean square velocity u_{rms} in a sample of our atmosphere at STP?**

a) Ar
b) CO_2
c) O_2
d) CH_4
e) they have all the same u_{rms}

Q7 **Argon effuses into a vacuum with a rate of 20mL/min. An unknown gas under the same conditions effuses with a rate of 30.7mL /min. Which one of the following gases could it be?**

a) Ne
b) He
c) NH_3
d) UF_6
e) H_2

Q8 **Calculate the average kinetic energy of Methane (CH_4) in J/mol at t =25° C, P=1 atm**

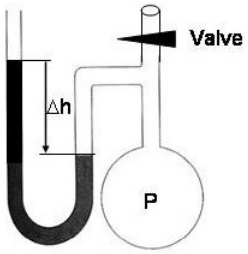
a) 3717 J/mol
b) 311 J/mol
c) 2477 J/mol
d) 22.4 J/mol
e) 36.68 J/mol

Q9 **What is the density in g/L of Helium (He) in a stratospheric weather balloon at an altitude of ca 15,000 m; t = - 43 ^{o}C, and P = 66,000 Pa**

a) 0.138 g/L
b) 14.01 g/L
c) 138 g/L
d) 0.000117 g/L
e) Additional information is needed

Q10 **What is the pressure in the closed container when you read a Δh of 125 mm on the open u-tube manometer filled with mercury at an atmospheric pressure of 101325 Pa?**

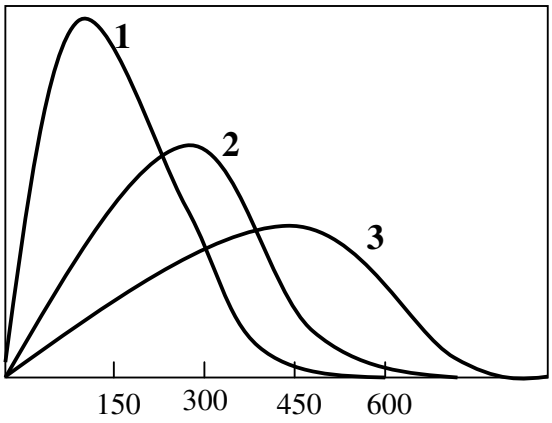
a) 117990 Pa
b) 84659 Pa
c) 16665 Pa
d) 125 torr
e) 760 torr



Q11 **The *a* value in the van der Waals equation for Xe is _____ than Ne. The *b* value of Ne is _____ than Ar. Fill in the blanks using the words, respectively:**

a) larger, larger
b) larger, smaller
c) smaller, larger
d) smaller, smaller
e) cannot be answered based on the information given

Q12 **Which one of the following statements *can be deduced* from the molecular distribution of speed graphs shown below, corresponding to 3 different gases having different molar masses M; the y-axis corresponds to the fraction of molecules with a particular speed:**



Molecular Speed u m/s

a) The average kinetic energy per mole of gas must be different for the three gases.
b) $M_1 < M_2 < M_3$ (M is the molar mass).
c) The temperature of Gas 3 must be higher than the temperature of Gas 1, otherwise its distribution function cannot be broader as shown.
d) The molecules of Gas 2 move at a speed of 300 m/s and collide with each other, as a result the molecules undergo only a change in direction. The pressure exerted on the wall is a function of the frequency of collisions and the speed at which the particles are moving.
e) All are false

Q13 Consider CO_2 and Ne under the following conditions:

Flask A, CO_2 (g)	Flask B, Ne (g)
2 moles	3 moles
740 K	370 K
0.50 atm	0.80 atm

Which of the following statements is *true*?

a) The volume CO_2 occupies is twice the volume occupied by Ne.
b) The force exerted when a CO_2 molecule collides with the walls is smaller than the force exerted when a Ne molecule collides with the walls.
c) The average kinetic of a Ne molecule is twice the average kinetic energy of CO_2 molecule.
d) The u_{rms} for the CO_2 molecules is smaller than the u_{rms} for the Ne molecules.
e) All are false

Q14 The valve between a 10-L tank containing a gas at 1 atm and a 3-L tank containing a gas at 0.5 atm is opened. Nothing else is changed in the environment. The two gases do not react. Calculate the final pressure in the tank:

a) 0.88 atm
b) 1.5 atm
c) 2.45 atm
d) 0.75 atm
e) Not enough information is given to solve for the final pressure.

Q15 The hybridization of I in ICl_4^- is:

a) sp
b) sp^2
c) sp^3
d) dsp^2
e) d^2sp^3

Q16 Which of the following molecules (C: central atom) contains the shortest C-O bond:

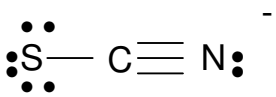
a) CH_3OH
b) CH_2O
c) CO
d) CO_2
e) CH_3CH_2OH

Q 17 Which of the following molecules has a resultant dipole moment $\mu \neq 0$?

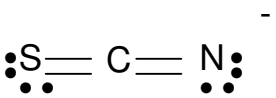
a) $CHCl_3$
b) BF_3
c) TeF_4
d) a and c
e) all of the above

Q18 Which of the following is expected to be the best resonance structure of SCN^-

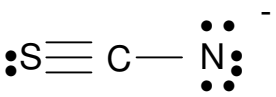
a)



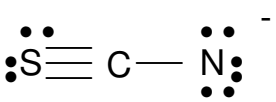
b)



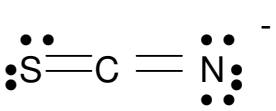
c)



d)



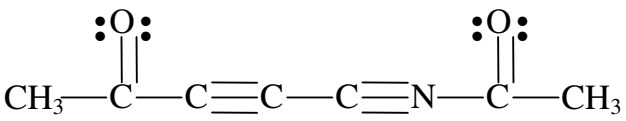
e)



19 Which of the following electron arrangement and molecular geometries around the central atom (1st atom is the central atom) correctly correspond to the molecule in question:

a) CO_2, electron arrangement: trigonal planar; geometry: bent
b) ClF_3, electron arrangement: octahedral; geometry: T-shaped
c) $XeCl_4$, electron arrangement: trigonal bipyramid; geometry: see-saw
d) XeF_2, electron arrangement: trigonal bipyramid; geometry: linear
e) b and c are correct

Q20 How many atoms are in the same plane for the following molecule?



a) 4
b) 5
c) 8
d) 9
e) 10

Periodic Table Of The Elements

1																	18
1 +1 20.268 14.025 0.0899¤ **H** Hydrogen 1.007 94 ±7	2											13	14	15	16	17	2 4.215 0.95 0.179¤ **He** Helium 4.002 602 ±2
3 +1 1615 454 0.53 **Li** Lithium 6.941 ±2†	4 +2 2745 1560 1.85 **Be** Beryllium 9.012 182 ±3											5 +3 4275 2300 2.34 **B** Boron 10.811 ±7	6 ±4,2 4470 4100 2.62 **C** Carbon 12.010 7 ±8	7 ±3,5,4,2 77.35 63.14 1.251¤ **N** Nitrogen 14.006 74 ±7	8 -2 90.18 50.35 1.429¤ **O** Oxygen 15.999 4 ±3	9 -1 84.95 53.48 1.696¤ **F** Fluorine 18.998 403 2 ±5	10 27.10 24.55 0.901¤ **Ne** Neon 20.179 7 ±6
11 +1 1156 371 0.97 **Na** Sodium 22.989 770 ±2	12 +2 1363 922 1.74 **Mg** Magnesium 24.305 0 ±6	3	4	5	6	7	8	9	10	11	12	13 +3 2793 933.25 2.7 **Al** Aluminum 26.981 538 ±2	14 +4 3540 1685 2.33 **Si** Silicon 28.085 5 ±3	15 ±3,5,4 550 317.3 1.82 **P** Phosphorus 30.973 761 ±2	16 ±2,4,6 717.8 388.4 2.07 **S** Sulfur 32.066 ±6	17 ±1,3,5,7 239.1 172.2 3.17¤ **Cl** Chlorine 35.452 7 ±9	18 87.3 83.81 1.784¤ **Ar** Argon 39.948
19 +1 1032 336 0.86 **K** Potassium 39.098 3	20 +2 1757 1112 1.55 **Ca** Calcium 40.078 ±4	21 +3 3104 1812 3.0 **Sc** Scandium 44.955 910 ±8	22 +4,3 3562 1943 4.5 **Ti** Titanium 47.867	23 +5,4,3,2 3682 2175 5.8 **V** Vanadium 50.941 5	24 +6,3,2 2945 2130 7.19 **Cr** Chromium 51.996 1 ±6	25 +7,6,4,2,3 2335 1517 7.43 **Mn** Manganese 54.938 049 ±9	26 +2,3 3135 1809 7.86 **Fe** Iron 55.845 ±2	27 +2,3 3201 1768 8.90 **Co** Cobalt 58.933 200 ±9	28 +2,3 3187 1726 8.90 **Ni** Nickel 58.693 4 ±2	29 +2,1 2836 1358 8.96 **Cu** Copper 63.546 ±3	30 +2 1180 693 7.14 **Zn** Zinc 65.39 ±2	31 +3 2478 303 5.91 **Ga** Gallium 69.723	32 +4 3107 1210 5.32 **Ge** Germanium 72.61 ±2	33 ±3,5 876 5.72 **As** Arsenic 74.921 60 ±2	34 -2,4,6 958 494 4.80 **Se** Selenium 78.96 ±3	35 ±1,5 332.25 265.90 3.12 **Br** Bromine 79.904	36 119.80 115.78 3.74¤ **Kr** Krypton 83.80
37 +1 961 313 1.53 **Rb** Rubidium 85.467 8 ±3	38 +2 1650 1041 2.6 **Sr** Strontium 87.62	39 +3 3611 1799 4.5 **Y** Yttrium 88.905 85 ±2	40 +4 4682 2125 6.49 **Zr** Zirconium 91.224 ±2	41 +5,3 5017 2740 8.55 **Nb** Niobium 92.906 38 ±2	42 +6,5,4,3,2 4912 2890 10.2 **Mo** Molybdenum 95.94	43 +7 4538 2473 11.5 **Tc** Technetium (99)	44 +2,3,4,6,8 4423 2523 12.2 **Ru** Ruthenium 101.07 ±2	45 +2,3,4 3970 2236 12.4 **Rh** Rhodium 102.905 50 ±2	46 +2,4 3237 1825 12.0 **Pd** Palladium 106.42	47 +1 2436 1234 10.5 **Ag** Silver 107.868 2 ±2	48 +2 1040 594 8.65 **Cd** Cadmium 112.411 ±8	49 +3 2346 430 7.31 **In** Indium 114.818 ±3	50 +4,2 2876 505 7.30 **Sn** Tin 118.710 ±7	51 ±3,5 1860 904 6.68 **Sb** Antimony 121.760	52 -2,4,6 1261 723 6.24 **Te** Tellurium 127.60 ±3	53 ±1,5,7 458 387 4.92 **I** Iodine 126.904 47 ±3	54 165 161 5.89¤ **Xe** Xenon 131.29 ±2
55 +1 944 302 1.87 **Cs** Cesium 132.905 45 ±2	56 +2 2171 1002 3.5 **Ba** Barium 137.327 ±7	57 +3 3730 1193 6.7 **La** Lanthanum 138.905 5 ±2	72 +4 4876 2500 13.1 **Hf** Hafnium 178.49 ±2	73 +5 5731 3287 16.6 **Ta** Tantalum 180.947 9	74 +6,5,4,3,2 5828 3680 19.3 **W** Tungsten 183.84	75 +7,6,4,2,-1 5869 3453 21.0 **Re** Rhenium 186.207	76 +2,3,4,6,8 5285 3300 22.4 **Os** Osmium 190.23 ±3	77 +2,3,4,6 4701 2716 22.5 **Ir** Iridium 192.217±3	78 +2,4 4100 2045 21.4 **Pt** Platinum 195.078 ±2	79 +3,1 3130 1338 19.3 **Au** Gold 196.966 55 ±2	80 +2,1 630 234 13.5 **Hg** Mercury 200.59 ±2	81 +3,1 1746 577 11.85 **Tl** Thallium 204.383 3 ±2	82 +4,2 2023 601 11.4 **Pb** Lead 207.2	83 +3,5 1837 545 9.8 **Bi** Bismuth 208.980 38 ±2	84 +4,2 1235 527 9.4 **Po** Polonium (~210)	85 ±1,3,5,7 610 575 — **At** Astatine (~210)	86 211 202 9.91¤ **Rn** Radon (~222)
87 +1 950 300 — **Fr** Francium (223)	88 +2 1809 973 5 **Ra** Radium (226)	89 +3 3473 1323 10.07 **Ac** Actinium (227)	104 — **Rf** Rutherfordium (261)	105 — **Db** Dubnium (262)	106 — **Sg** Seaborgium (266)	107 — **Bh** Bohrium (262)	108 — **Hs** Hassium (265)	109 — **Mt** Meitnerium (266)									

Atomic Number
Boiling point (K)
Melting point (K)
Density at 300 K (g /cm^3)
(Densities marked with ¤ are at 273 K and 1 atm and the units are g/L)

22 +4,3 — Oxidation states (Bold is most stable state)
3562
1943
4.5
Ti
Titanium
47.867

Atomic mass is accurate to ±1 in last decimal place unless otherwise indicated

Examples:
Ti = 47.867 ± 0.001
Fe = 55.845 ± 0.002

[Atomic masses from *Pure Appl. Chem.* 1996, *68*, 2339]

†Commercial lithium compounds are artificially depleted of ^{6}Li. The atomic mass of commercial Li is in the range 6.94 - 7.00. [H. P. Qi, T. B. Coplen, Q. Z. Wang and Y. H. Wang, *Anal. Chem.* 1997, *69*, 4076.]

58 +3,4 3699 1071 6.78 **Ce** Cerium 140.116	59 +3,4 3785 1204 6.77 **Pr** Praseodymium 140.907 65 ±2	60 +3 3341 1289 7.00 **Nd** Neodymium 144.24 ±3	61 +3 3785 1204 6.48 **Pm** Promethium (145)	62 +3,2 2064 1345 7.54 **Sm** Samarium 150.36 ±3	63 +3,2 1870 1090 5.26 **Eu** Europium 151.964
90 +4 5061 2028 11.7 **Th** Thorium 232.038 1	91 +5,4 — 15.4 **Pa** Protactinium 231.035 88 ±2	92 +6,5,4,3 4407 1405 18.90 **U** Uranium 238.028 9	93 +6,5,4,3 — 910 20.4 **Np** Neptunium 237.048 2	94 +6,5,4,3 3503 913 19.8 **Pu** Plutonium (244)	95 +6,5,4,3 2880 1268 13.6 **Am** Americium (243)

64 +3 3539 1585 7.89 **Gd** Gadolinium 157.25 ±3	65 +3 3496 1630 8.27 **Tb** Terbium 158.925 34 ±2	66 +3 2835 1682 8.54 **Dy** Dysprosium 162.50 ±3	67 +3 2968 1743 8.80 **Ho** Holmium 164.930 32 ±2	68 +3 3136 1795 9.05 **Er** Erbium 167.26 ±3	69 +3,2 2220 1818 9.33 **Tm** Thulium 168.934 21 ±2	70 +3,2 1467 1097 6.98 **Yb** Ytterbium 173.04 ±3	71 +3 3668 1936 9.84 **Lu** Lutetium 174.967
96 +3 — 1340 13.51 **Cm** Curium (247)	97 +4,3 — — **Bk** Berkelium (247)	98 +3 — 900 — **Cf** Californium (251)	99 — — **Es** Einsteinium (254)	100 — — **Fm** Fermium (257)	101 — — **Md** Mendelevium (260)	102 — — **No** Nobelium (259)	103 — — **Lr** Lawrencium (262)