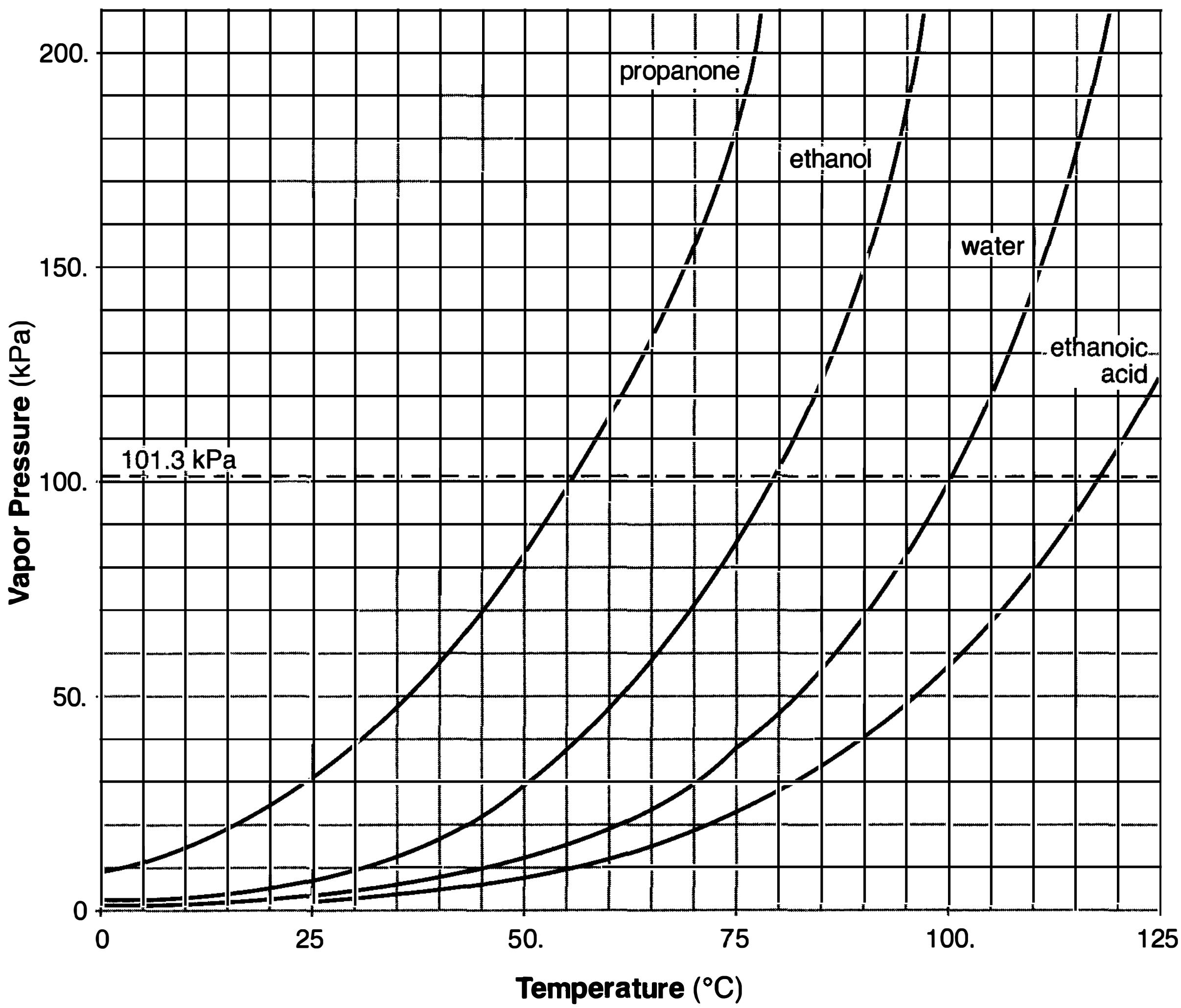
Review of Reference Tables!

Step 1: Read the information text and take notes

Step 2: Answer the Practice Questions

Table H — Vapor Pressure of Four Liquids



Overview:

A liquid is the form of matter that has definite volume but no definite shape. A liquid takes the shape of the container it is in. Above the surface of a liquid, there is always found the gaseous form of that liquid, called a vapor. The term vapor refers to the gas phase of a substance that is ordinarily a solid or liquid at that temperature. This vapor above the surface of a liquid exerts a characteristic pressure called vapor pressure.

The Table:

This table shows the vapor pressure, in kPa, of four liquids as a function of temperature. The graph shows that propanone has the greatest vapor pressure at any given temperature compared to the other three liquids, while ethanoic acid has the lowest vapor pressure at any given temperature compared to the other three liquids. To determine the vapor pressure of a liquid at a specific temperature, move directly up from the given temperature until you reach the intersection point of the liquid's vapor pressure curve. Reading across to the vapor pressure axis gives the vapor pressure of that liquid at that temperature. The dotted horizontal line labeled 101.3 kPa is standard pressure (see Table A).

Temperature vs. Vapor Pressure

As the temperature increases, the vapor pressure increases. This is due to an increased amount of vapor and the greater average kinetic energy of the vapor particles. As the pressure on the surface of a liquid increases, the boiling point of the liquid increases. This is caused by the need to reach a higher vapor pressure to equal the increased pressure on the surface of the liquid.

Boiling Point and Vapor Pressure

The boiling point of a liquid is the temperature at which the vapor pressure is equal to the atmospheric pressure on the surface of the liquid. Therefore, when a liquid is boiling, the atmospheric pressure on the liquid can be read from the vapor pressure axis since they are equal to each other. When the atmospheric pressure is equal to standard pressure, the boiling point is called the normal boiling point. Reading from the graph at standard pressure (101.3 kPa), the normal boiling points of propanone, ethanol, water and ethanoic acid are 56°C, 79°C, 100°C and 117°C, respectively.

Intermolecular Attraction

A higher boiling point for a liquid indicates a greater attraction between the molecules of that liquid. The vapor pressure curves on Table H indicate that propanone has the weakest intermolecular attraction and ethanoic acid has the greatest intermolecular attraction.

Additional Information:

- The vapor pressure depends only upon the nature of the liquid and the temperature. It does not depend upon the amount of liquid.

- If a temperature-pressure point lies on one of the vapor pressure curves, the liquid is boiling, changing from the liquid to the gas phase. If the intersection point of the temperature and atmospheric pressure (read from the vapor pressure axis) of the substance is to the left of its vapor pressure curve, that substance is a liquid. If the intersection point lies to the right of the vapor pressure curve, it is a gas. For example, at 25°C and 150 kPa pressure, propanone is in the liquid phase, while at 25°C and 20 kPa pressure, propanone is in the gaseous phase.

18. A liquid's boiling point is the temperature at which its vapor pressure is equal to the atmospheric pressure. Using Reference Table H, what is the boiling point of propanone at an atmospheric pressure of 70 kPa?

____

19. Explain, in terms of molecular energy, why the vapor pressure of propanone increases when its temperature increases.

____

____

____

20. The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is equal to the pressure on the surface of the liquid. The heat of vaporization of ethanol is 838 joules per gram. A sample of ethanol has a mass of 65.0 grams and is boiling at 1.00 atmosphere.

Based on Table H, what is the temperature of this sample of ethanol? ____________________

21. A sample of ethanoic acid is at 85°C. At a pressure of 50 kPa, what increase in temperature is needed to reach the boiling point of ethanoic acid? __________

22. Based on Reference Table H, which substance has the:

strongest intermolecular forces – ________________________

weakest intermolecular forces – ________________________

23. At 70 kPa, determine the boiling point of:

propanone – ______________ °C

ethanol – ________________ °C

water – _________________ °C

ethanoic acid – ____________ °C

Periodic Table of The Elements

Overview:

The Periodic Table is a systematic arrangement or classification of the elements. In the late 1800's, scientists noticed regularities in the properties of the elements, prompting them to arrange the elements based upon these recurring properties. It has passed through many stages of development in reaching its present form. This arrangement enabled scientists to predict the chemical and physical properties of elements that had not yet been discovered. This table will enable you to determine the identity of an element when given the properties of that element. The modern Periodic Law states that the properties of the elements are periodic functions of the atomic number or nuclear charge.

The Key:

Symbol – The symbol is a shorthand method of indicating the identity of the element. It consists of one or two letters from its name in English, or in many cases, from its name in Latin. The first letter is always capitalized, and the second letter (if present) is always written in lower case.

Atomic mass – The atomic mass of an element is the weighted average mass of the naturally occurring isotopes of that element. It is weighted according to the percent occurrence of each isotope. Atomic mass is expressed in atomic mass units (u). The atomic mass unit is defined relative to the mass of a C-12 atom, assigned an atomic mass of exactly 12.000 u. One atomic mass unit is 1/12 the mass of the standard C-12 atom. Since most elements occur as a mixture of isotopes, their atomic masses are decimal or fractional. It is calculated by taking the sum of the products of the percent occurrence and actual mass of each isotope. For example, Cl exists naturally as 75.40% Cl-35 (actual mass = 34.97) and 24.60% Cl-37 (actual mass = 36.97). The atomic mass of chlorine is: $(0.7540 \times 34.97) + (0.2460 \times 36.97) = 35.46$ u.

Atomic number – The atomic number of an element is the number of protons in the nucleus of an atom of that element. It is the property that identifies the element. Isotopes are atoms with the same atomic number but different mass numbers (the number of protons and neutrons in the nucleus). For example, C-12 and C-14 are isotopes. Both have 6 protons but C-12 has 6 neutrons while C-14 has 8 neutrons. The positive charge of a nucleus is equal to its atomic number.

Electron Configuration – The electron configuration given for the element shows the number of electrons in each principal energy level of an atom of that element in the ground state. The ground state is the state of lowest energy for the electrons in an atom.

Selected Oxidation States – The selected oxidation states (also referred to as oxidation number) show the charge on an atom of that element after gaining or losing an electron(s), or the apparent charge resulting from an unequal sharing of electrons with another atom. A loss of electrons (oxidation) results in a positive oxidation state. A gain of electrons (reduction) results in a negative oxidation state. Sharing of electrons with an atom of higher electronegativity results in a positive oxidation state. Sharing of electrons with an atom of lower electronegativity results in a negative oxidation state.

The Periodic Table:

Periods – The horizontal rows on the table are called periods. The properties of the elements change systematically through a period. With increasing atomic number in a given period, the properties of the elements change from metallic to metalloid to nonmetallic to inert (noble) gas. The exception is Period 1, where both elements are nonmetals. The period number is equal to the number of occupied energy levels of an atom in its ground state.

Groups – The vertical columns on the table are called groups or families. The elements in a group exhibit similar or related properties because they contain the same number of valence electrons. For example, Na and K would have similar chemical properties since they are both located in Group 1 and contain one valence electron. The Group 1 elements are called the alkali metals. Those in Group 2 are the alkaline earth elements. Group 17 elements are the halogens and those in Group 18 are the inert, rare or noble gases. The inert gases are chemically inactive, forming compounds only with the most active elements (F and O). All are monatomic gases at room conditions.

Valence Electrons – The period number is the same as the number of occupied energy levels of an atom in its ground state. The outer most energy level (last number in the electron configuration) is the valence level and the electrons in this energy level are the valence electrons. These electrons are the electrons lost, gained or shared during a chemical reaction, and therefore determine the chemical properties of the elements. For example: Lithium (Li) is in Period 2. It contains two principal energy levels and has one valence electron.

Classification of the Elements – The dark zig-zag line on the Periodic Table separates the metals from the nonmetals. Elements bordering this line, especially those to the right of the line, are called metalloids, and have properties of both metals and nonmetals. Most of the elements on the Periodic Table are metals and are found to the left of the zig-zag line. Metals are malleable, ductile, possess luster, and are good conductors of heat and electricity. All are solids at room temperature except mercury, which is a liquid. Metals lose electrons to form positive ions when reacting with nonmetals. The remaining elements are nonmetals and are found to the right of the zig-zag line. Nonmetals are brittle, lack luster and are nonconductors of heat and electricity. At room temperature, they exhibit all three phases of matter. Bromine is the only nonmetal that is a liquid at room temperature. Nonmetals tend to gain electrons during ionic bond formation, but they can form either positive or negative oxidation states during covalent bond formation with another nonmetal.

Additional Information:

- Rounding off the atomic mass to the nearest whole number gives the atomic mass number or simply the mass number of the element. The mass number is the number of protons and neutrons (nucleons) in the nucleus of an atom of that element. Due to the weighting used in calculating the atomic mass of an element, this gives the mass number of the most common isotope of that element.

19. The atomic mass unit is defined as exactly $\frac{1}{12}$ the mass of an atom of

(1) $^{12}_{6}C$ (3) $^{24}_{12}Mg$
(2) $^{14}_{6}C$ (4) $^{26}_{12}Mg$ 19 ____

20. Which element forms a compound with chlorine with the general formula MCl?

(1) Rb (3) Re
(2) Ra (4) Rn 20 ____

21. In comparison to an atom of $^{19}_{9}F$ in the ground state, an atom of $^{12}_{6}C$ in the ground state has

(1) three fewer neutrons
(2) three fewer valence electrons
(3) three more neutrons
(4) three more valence electrons 21 ____

Base your answers to question 22 on the information below.

In the modern model of the atom, each atom is composed of three major subatomic (or fundamental) particles.

22. *a*) Name the subatomic particles contained in the nucleus of the atom.

____

b) State the charge associated with each type of subatomic particle contained in the nucleus of the atom. ____

c) What is the net charge of the nucleus? ______________

23. State, in terms of subatomic particles, how an atom of C-13 is different from an atom of C-12.

____

24. Explain, in terms of atomic particles, why S-32 is a stable nuclide.

____

25. In the early 1900s, experiments were conducted to determine the structure of the atom. One of these experiments involved bombarding gold foil with alpha particles. Most alpha particles passed directly through the foil. Some, however, were deflected at various angles. Based on this alpha particle experiment, state two conclusions that were made concerning the structure of an atom.

Conclusion 1 ____

Conclusion 2 ____

Table S — Properties of Selected Elements

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm^3)	Atomic Radius (pm)
1	H	hydrogen	1312	2.2	14	20.	0.000082	32
2	He	helium	2372	—	—	4	0.000164	37
3	Li	lithium	520.	1.0	454	1615	0.534	130.
4	Be	beryllium	900.	1.6	1560.	2744	1.85	99
5	B	boron	801	2.0	2348	4273	2.34	84
6	C	carbon	1086	2.6	—	—	—	75
7	N	nitrogen	1402	3.0	63	77	0.001145	71
8	O	oxygen	1314	3.4	54	90.	0.001308	64
9	F	fluorine	1681	4.0	53	85	0.001553	60.
10	Ne	neon	2081	—	24	27	0.000825	62
11	Na	sodium	496	0.9	371	1156	0.97	160.
12	Mg	magnesium	738	1.3	923	1363	1.74	140.
13	Al	aluminum	578	1.6	933	2792	2.70	124
14	Si	silicon	787	1.9	1687	3538	2.3296	114
15	P	phosphorus (white)	1012	2.2	317	554	1.823	109
16	S	sulfur (monoclinic)	1000.	2.6	388	718	2.00	104
17	Cl	chlorine	1251	3.2	172	239	0.002898	100.
18	Ar	argon	1521	—	84	87	0.001633	101
19	K	potassium	419	0.8	337	1032	0.89	200.
20	Ca	calcium	590.	1.0	1115	1757	1.54	174
21	Sc	scandium	633	1.4	1814	3109	2.99	159
22	Ti	titanium	659	1.5	1941	3560.	4.506	148
23	V	vanadium	651	1.6	2183	3680.	6.0	144
24	Cr	chromium	653	1.7	2180.	2944	7.15	130.
25	Mn	manganese	717	1.6	1519	2334	7.3	129
26	Fe	iron	762	1.8	1811	3134	7.87	124
27	Co	cobalt	760.	1.9	1768	3200.	8.86	118
28	Ni	nickel	737	1.9	1728	3186	8.90	117
29	Cu	copper	745	1.9	1358	2835	8.96	122
30	Zn	zinc	906	1.7	693	1180.	7.134	120.
31	Ga	gallium	579	1.8	303	2477	5.91	123
32	Ge	germanium	762	2.0	1211	3106	5.3234	120.
33	As	arsenic (gray)	944	2.2	1090.	—	5.75	120.
34	Se	selenium (gray)	941	2.6	494	958	4.809	118
35	Br	bromine	1140.	3.0	266	332	3.1028	117
36	Kr	krypton	1351	—	116	120.	0.003425	116
37	Rb	rubidium	403	0.8	312	961	1.53	215
38	Sr	strontium	549	1.0	1050.	1655	2.64	190.
39	Y	yttrium	600.	1.2	1795	3618	4.47	176
40	Zr	zirconium	640.	1.3	2128	4682	6.52	164

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm^3)	Atomic Radius (pm)
41	Nb	niobium	652	1.6	2750.	5017	8.57	156
42	Mo	molybdenum	684	2.2	2896	4912	10.2	146
43	Tc	technetium	702	2.1	2430.	4538	11	138
44	Ru	ruthenium	710.	2.2	2606	4423	12.1	136
45	Rh	rhodium	720.	2.3	2237	3968	12.4	134
46	Pd	palladium	804	2.2	1828	3236	12.0	130.
47	Ag	silver	731	1.9	1235	2435	10.5	136
48	Cd	cadmium	868	1.7	594	1040.	8.69	140.
49	In	indium	558	1.8	430.	2345	7.31	142
50	Sn	tin (white)	709	2.0	505	2875	7.287	140.
51	Sb	antimony (gray)	831	2.1	904	1860.	6.68	140.
52	Te	tellurium	869	2.1	723	1261	6.232	137
53	I	iodine	1008	2.7	387	457	4.933	136
54	Xe	xenon	1170.	2.6	161	165	0.005366	136
55	Cs	cesium	376	0.8	302	944	1.873	238
56	Ba	barium	503	0.9	1000.	2170.	3.62	206
57	La	lanthanum	538	1.1	1193	3737	6.15	194
Elements 58–71 have been omitted.								
72	Hf	hafnium	659	1.3	2506	4876	13.3	164
73	Ta	tantalum	728	1.5	3290.	5731	16.4	158
74	W	tungsten	759	1.7	3695	5828	19.3	150.
75	Re	rhenium	756	1.9	3458	5869	20.8	141
76	Os	osmium	814	2.2	3306	5285	22.587	136
77	Ir	iridium	865	2.2	2719	4701	22.562	132
78	Pt	platinum	864	2.2	2041	4098	21.5	130.
79	Au	gold	890.	2.4	1337	3129	19.3	130.
80	Hg	mercury	1007	1.9	234	630.	13.5336	132
81	Tl	thallium	589	1.8	577	1746	11.8	144
82	Pb	lead	716	1.8	600.	2022	11.3	145
83	Bi	bismuth	703	1.9	544	1837	9.79	150.
84	Po	polonium	812	2.0	527	1235	9.20	142
85	At	astatine	—	2.2	575	—	—	148
86	Rn	radon	1037	—	202	211	0.009074	146
87	Fr	francium	393	0.7	300.	—	—	242
88	Ra	radium	509	0.9	969	—	5	211
89	Ac	actinium	499	1.1	1323	3471	10.	201
Elements 90 and above have been omitted.								

*boiling point at standard pressure

** density of solids and liquids at room temperature and density of gases at 298 K and 101.3 kPa

— no data available

Source: *CRC Handbook for Chemistry and Physics*, 91st ed., 2010–2011, CRC Press

Overview:

This table shows some important chemical and physical properties of selected elements. These properties may be used to predict chemical reactivity, bond type, the phase of the element at a given temperature, the identity of an element and the ionic radius of an element.

The Table:

The *Atomic Number, Symbol* and *Name* of the selected elements are given in the first three columns. The elements are listed in order of increasing atomic number.

The *First Ionization Energy* is defined as the energy required to remove the most loosely bound (outermost) electron from an atom. This electron is an electron in the valence level of the atom. It is measured in kilojoules/mole (kJ/mol) of atoms.

The *Electronegativity* of an atom is the measure of the relative ability of that atom to attract bonding electrons to itself. It is measured relative to that of fluorine (F), assigned a value of 4.0, the highest electronegativity of all the elements. Since it is a relative measurement, there is no unit for electronegativity. Notice that there is no value listed for He, Ne, Ar, Kr and Rn. These elements are inert or noble gases and do not form chemical bonds with other elements. There is however a value listed for Xe, another inert gas, since Xe does form compounds with the most active elements, F and O.

The *Melting Point* is the temperature at which the solid changes to a liquid. Notice that the melting point is expressed on the Kelvin (K) temperature scale. The melting point and freezing point for an element are the same.

The *Boiling Point* is the temperature at which the liquid changes to the gas phase. It is expressed on the Kelvin scale also. Note at the bottom of the table that the boiling point is measured at standard pressure and is therefore the normal boiling point of the element. The boiling point and the condensation point for an element are the same.

The *Density* of a substance is defined as the mass per unit volume. It is expressed in units of gram/cubic centimeter (g/cm^3). Note at the bottom of the table that the density of solids and liquids are measured at room temperature and the densities of gases at 298 K and 101.3 kPa.

The *Atomic Radius* is an estimate of the size of an atom or the distance from the center of the nucleus to the edge of the atom. It is an estimate due to the fact the outer edge of an atom is not distinct. Atomic radii are measured in picometers (pm–see Table C).

Set 1 – First Ionizaton Energy

1. Which noble gas has the highest first ionization energy?

(1) radon (3) neon
(2) krypton (4) helium 1 _____

2. According to Reference Table *S*, which sequence correctly places the elements in order of increasing ionization energy?

(1) H → Li → Na → K
(2) I → Br → Cl → F
(3) O → S → Se → Te
(4) H → Be → Al → Ga 2 _____

3. As the elements of Group 1 on the Periodic Table are considered in order of increasing atomic radius, the ionization energy of each successive element generally

(1) decreases
(2) increases
(3) remains the same 3 _____

4. Samples of four Group 15 elements, antimony, arsenic, bismuth, and phosphorus, are in the gaseous phase. An atom in the ground state of which element requires the least amount of energy to remove its most loosely held electron?

(1) As (3) P
(2) Bi (4) Sb 4 _____

5. What are two properties of most nonmetals?
(1) high ionization energy and poor electrical conductivity
(2) high ionization energy and good electrical conductivity
(3) low ionization energy and poor electrical conductivity
(4) low ionization energy and good electrical conductivity 5 _____

6. Which two characteristics are associated with metals?

(1) low first ionization energy and low electronegativity
(2) low first ionization energy and high electronegativity
(3) high first ionization energy and low electronegativity
(4) high first ionization energy and high electronegativity 6 _____

7. Which general trend is found in Period 2 on the Periodic Table as the elements are considered in order of increasing atomic number?

(1) increasing first ionization energy
(2) decreasing atomic mass
(3) decreasing electronegativity
(4) increasing atomic radius 7 _____

8. Explain, in terms of atomic structure, why cesium has a lower first ionization energy than rubidium.

____

____