Chemistry SAT II Subject Test

Test Basics

Scoring, Timing, Number of Questions		
Points	**Minutes**	**Questions**
200-800	60	85 *(generally 70 multiple choice and 15 True/False)*

Important Notes

- Calculator use **not** permitted
- Problem solving requires simple numerical calculations
- Measurements are expressed in the metric system
- A periodic table is provided on the test
- *There is a guessing penalty. A quarter point is deducted for each incorrect answer. Your "raw" score is calculated by taking the total number of correct responses and subtracting the total number of incorrect responses, divided by four. The raw score is converted into your "scaled score" out of 800 as shown below.*

THE PRINCETON REVIEW PRACTICE SAT CHEMISTRY SUBJECT TEST SCORE CONVERSION TABLE

Raw Score	Scaled Score	Raw Score	Scaled Score	Raw Score	Scaled Score
85	800	45	620	5	390
84	800	44	620	4	390
83	800	43	610	3	380
82	800	42	610	2	380
81	800	41	600	1	370
80	800	40	590	0	370
79	800	39	590	−1	370
78	790	38	580	−2	360
77	780	37	580	−3	360
76	780	36	570	−4	350
75	780	35	560	−5	340
74	780	34	560	−6	340
73	780	33	550	−7	330
72	770	32	550	−8	330
71	770	31	540	−9	320
70	750	30	530	−10	310
69	750	29	530	−11	310
68	740	28	520	−12	300
67	740	27	520	−13	300
66	740	26	520	−14	290
65	730	25	510	−15	280
64	730	24	510	−16	280
63	710	23	500	−17	270
62	710	22	500	−18	270
61	710	21	490	−19	260
60	700	20	480	−20	250
59	700	19	480	−21	250
58	690	18	470		
57	690	17	470		
56	680	16	460		
55	680	15	450		
54	680	14	450		
53	670	13	440		
52	670	12	440		
51	660	11	430		
50	650	10	420		
49	650	9	420		
48	630	8	410		
47	630	7	410		
46	630	6	400		

Topics on the Test **Content**	**Approximate % of Test**
Structure of matter • **Atomic Structure**, including experimental evidence of atomic structure, quantum numbers and energy levels (orbitals), electron configurations, periodic trends • **Molecular Structure**, including Lewis structures, three-dimensional molecular shapes, polarity • **Bonding**, including ionic, covalent, and metallic bonds, relationships of bonding to properties and structures; intermolecular forces such as hydrogen bonding, dipole-dipole forces, London dispersion forces	25%
States of matter • **Gases**, including the kinetic molecular theory, gas law relationships, molar volumes, density, and stoichiometry • **Liquids and Solids**, including intermolecular forces in liquids and solids, types of solids, phase changes, and phase diagrams • **Solutions**, including molarity, molality, and percent by mass concentrations, solution preparation and stoichiometry, factors affecting solubility of solids, liquids, and gases, and colligative properties	16%
Reaction types • **Acids and Bases**, including Brønsted-Lowry theory, strong and weak acids and bases, pH, titrations, indicators • **Oxidation-Reduction**, including recognition of oxidation-reduction reactions, combustion, oxidation numbers, use of activity series • **Precipitation**, including basic solubility rules	14%
Stoichiometry • **Mole Concept**, including molar mass, Avogadro's number, empirical and molecular formulas • **Chemical Equations**, including the balancing of equations, stoichiometric calculations, percent yield, and limiting reactants	14%
Equilibrium and reaction rates • **Equilibrium Systems**, including factors affecting position of equilibrium (Le Châtelier's principle) in gaseous and aqueous systems, equilibrium constants, and equilibrium expressions • **Rates of Reactions**, including factors affecting reaction rates, potential energy diagrams, activation energies	5%
Thermochemistry • Including conservation of energy, calorimetry and specific heats, enthalpy (heat) changes associated with phase changes and chemical reactions, heating and cooling curves, entropy	6%
Descriptive chemistry • Including common elements, nomenclature of ions and compounds, periodic trends in chemical and physical properties of the elements, reactivity of elements and prediction of products of chemical reactions, examples of simple organic compounds and compounds of environmental concern	12%
Laboratory • Including knowledge of laboratory equipment, measurements, procedures, observations, safety, calculations, data analysis, interpretation of graphical data, drawing conclusions from observations and data	8%

Sample True/False/ "Correct Explanation" Questions

Each of the following questions consists of two statements, I in the left-hand column and II in the right-hand column. For each question, determine whether statement I is true or false and whether statement II is true or false. If BOTH statements are TRUE, circle CE only if statement II is a correct explanation of the true statement I.

(1)

A molecule of silicon tetrachloride, $SiCl_4$, is nonpolar	BECAUSE	the four bonds in $SiCl_4$ are identical and the molecule has a tetrahedral structure.

(2)

An element that has the electron configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$ is a transition element	BECAUSE	in atoms of transition elements, the 1s, 2*s*, 2*p*, 3*s*, and 3*p* orbitals are completely filled in the ground state.

(3)

The combustion of fuels containing sulfur leads to the production of acid rain	BECAUSE	sulfur oxides form acid solutions in water

(4)

At the same temperature and pressure, 1 L of hydrogen gas and 1 L of neon gas have the same mass	BECAUSE	equal volumes of ideal gases at the same temperature and pressure contain the same number of moles

(5)

$HC_2H_3O_2 + H_2O \rightleftarrows C_2H_3O_2^- + H_3O^+$ If some acetic acid, $HC_2H_3O_2$ is added to the equilibrium mixture represented by the equation above, the concentration of H_3O^+ decreases	BECAUSE	the equilibrium constant of the reaction changes when the concentration of a reactant changes

Question	I		II		CE
1	T	F	T	F	CE
2	T	F	T	F	CE
3	T	F	T	F	CE
4	T	F	T	F	CE
5	T	F	T	F	CE

True/False
(1) T T CE
(2) T T
(3) T T CE
(4) F T
(5) F F

DO NOT DETACH FROM BOOK.

PERIODIC TABLE OF THE ELEMENTS

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.012											5 B 10.811	6 C 12.011	7 N 14.007	8 O 16.00	9 F 19.00	10 Ne 20.179
11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.10	20 Ca 40.48	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.938	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.91	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 *La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.2	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.02	89 †Ac 227.03	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 § (269)	111 § (272)	112 § (272)						

§ Not yet named

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	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 (260)

*Lanthanide Series

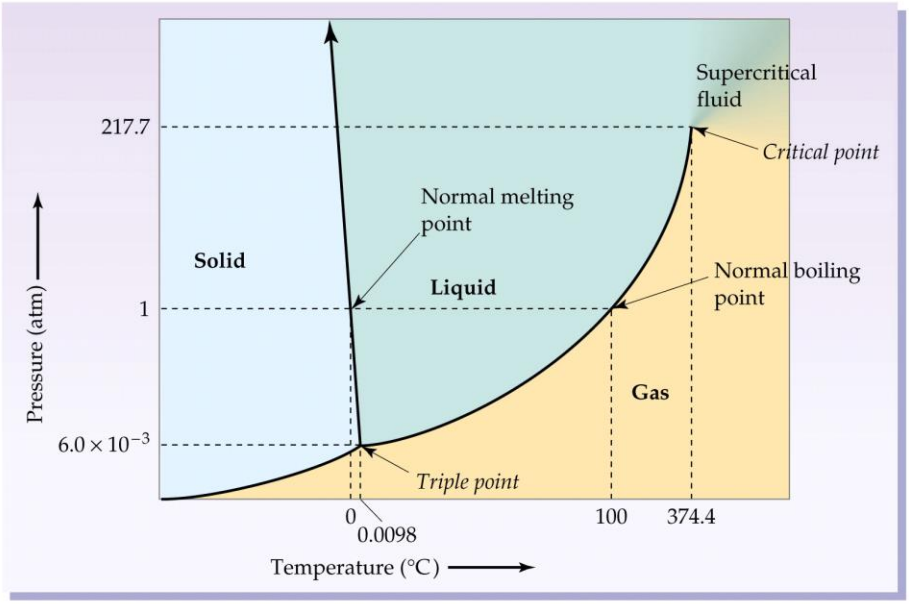
†Actinide Series

GO ON TO THE NEXT PAGE

Additional Topics for SAT II Chemistry Test

(1) **Phase Diagrams**
Show the phases of a substance for a range of temperatures and pressures.

ex. Consider the phase diagram for water.



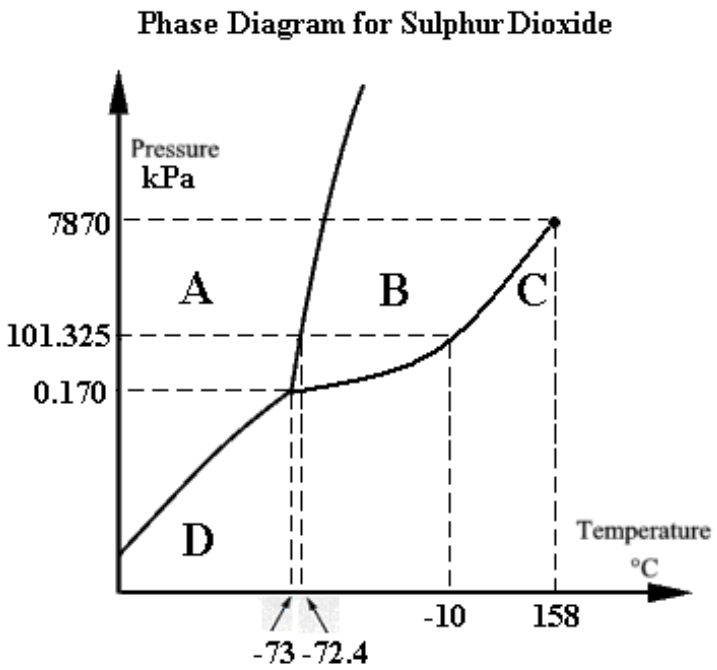
Normal melting point: the temperature at which the substance will melt at 1.00 atm.
(ex. the normal melting point of water is 0 ºC)

Normal boiling point: the temperature at which the substance will boil at 1.00 atm.
(ex. the normal boiling point of water is 100 ºC)

Triple point: the temperature and pressure at which the solid, liquid, and gas phases are all in equilibrium.
(ex. the triple point for water is 0.0060 atm and 0.0098 ºC)

Critical point: the temperature and pressure at which the liquid and gas phase are no longer distinguishable. Matter beyond the critical point exists as a *supercritical fluid*. Supercritical fluid displays some properties of a liquid (ie. it is a good solvent) and some properties of a gas (ie. it readily diffuses). (ex. the critical point for water is 217.7 atm and 374.4 ºC)

ex. Consider the phase diagram for sulphur dioxide.



(1) What phase of matter is present at each of the following points?
A: B: C:

(2) (a) What is the normal melting point for sulphur dioxide?

(b) What is the normal boiling point for sulphur dioxide?

(c) What is the triple point for sulphur dioxide?

(d) What is the critical point for sulphur dioxide?

(3) What process is occurring from
(a) point A to B? (b) point B to A?

(c) point B to C? (d) point C to B?

(e) point A to D? (f) point D to A?

(2) **Solution Concentration**
The concentration of a solution can be expressed as percent by mass or as "molality".

- *Percent by Mass*

Mass Percent: the mass of the solute, divided by the total mass of the solution.
Note: The mass of the solution is equal to the mass of the solute plus the mass of the solvent.

$$Mass\ Percent = \frac{mass\ of\ solute}{mass\ of\ solution} \times 100\%$$

- *Molality*

Molality: the number of moles of solute per kilogram of solvent. $Molality = \frac{mol\ solute}{kg\ solvent}$

Molality is measured in units called "molal", given the symbol "m" 1 m = 1 mol/kg
Molality is used for calculations related to Colligative Properties (see below).

ex. Calculate the concentration of a solution if 10.0 g of sodium chloride is dissolved in 200 g of water.
(a) In mass percent. (b) In molality.

(a)

$$Mass\ Percent = \frac{mass\ of\ solute}{mass\ of\ solution} \times 100\% = \frac{10.0\,g}{10.0\,g + 200\,g} \times 100\% = 4.76\%$$

(b) $10.0g\ x \frac{mol}{58.44\ g} = 0.171\ mol\ NaCl$ $200\ g\ x \frac{1kg}{1000\ g} = 0.200\ kg$

$$Molality = \frac{mol\ solute}{kg\ solvent} = \frac{0.171 mol}{0.200 kg} = 0.856 mol/kg = 0.856 m$$

(3) **Colligative properties**
Properties of a solution that depend on the number of solute particles.

- **Vapour Pressure of a Solution**

In general, the presence of a solute results in a solution having a ***lower*** vapour pressure than that of the pure solvent.

- **Boiling Point Elevation**

<u>The presence of a solute will increase the boiling point of the solvent</u>.
The increase boiling point of a solution can be calculated according to the following equation:

$$\Delta T_b = iK_b m$$

Where: ΔT_b = The difference between the boiling point of the solution and that of the pure solvent (°C)
i = van't Hoff factor, the number of particles in the solution for each solute molecule
(i will be equal 1 for non-electrolytes and can be approximated as 1 for weak electrolytes, for strong electrolytes, i is equal to the number of ions in solution)
K_b = The molal boiling point constant of the solvent (Water has K_b = 0.51 °C kg/mol)
m = the molality of the solute in the solution (mol/kg)

ex. Calculate the boiling point of a 0.90 molal solution of magnesium chloride in water.

Note: Magnesium chloride is an electrolyte and dissociates in solution according to the following equation: $MgCl_2 \rightarrow Mg^{2+} + 2Cl^-$
There are THREE ions present in solution, therefore i = 3.

$$\Delta T_b = iK_b m = (3)(0.51\,^\circ C\,kg/mol)(0.90\,m) = 1.4\,^\circ C$$

Since the boiling point *elevation* is 1.4 °C, the boiling point of the solution is 100 °C + 1.4 °C = 101.4 °C (HIGHER than that of pure water).

- **Freezing Point Depression**

<u>The presence of a solute will decrease the freezing point of the solvent</u>.
The decrease in freezing point of a solution can be calculated according to the following equation:

$$\Delta T_f = iK_f m$$

Where: ΔT_f = The difference between the freezing point of the solution and that of the pure solvent (°C)
i = number of particles in the solution for each solute molecule
(i will be equal 1 for non-electrolytes and can be approximated as 1 for weak electrolytes, for strong electrolytes, i is equal to the number of ions in solution)
K_f = The molal freezing point constant of the solvent (Water has K_f = 1.86 °C kg/mol)
m = the molality of the solute in the solution (mol/kg)

ex. Calculate the freezing point of a 1.5 molal solution of sucrose.
Sucrose is a non-electrolyte and will therefore have i = 1.

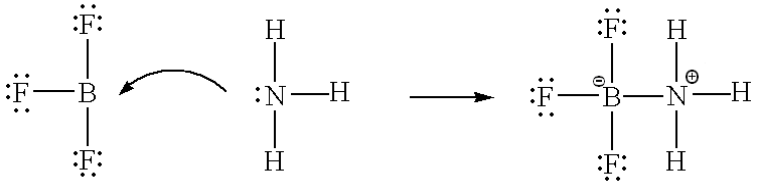
$$\Delta T_f = iK_f m = (1)(1.86\,^{\circ}C\,kg/mol)(1.5\,m) = 2.8\,^{\circ}C$$

Since the freezing point *depression* is 2.8 °C, the freezing point of the solution is 0 °C – 2.8 °C = –2.8 °C (LOWER than that of pure water).

(4) **Heat Energy in calories**
A calorie is a unit of energy equal to 4.18 J. A calorie is the amount of heat energy required to increase the temperature of 1 g of water by 1 ºC. (i.e. the specific heat capacity of water is 1 calorie/g ºC)
ex. Calculate the heat energy in calories required to increase the temperature of 20 g of water from 10 ºC to 40 ºC

$$\Delta H = mc\Delta T = (20\ g)\left(\frac{1\text{calorie}}{\text{g}}\text{℃}\right)(30\ \text{℃}) = 600\ calories$$

(5) **Acid Base Definitions**

Definition	Acid	Base	Example Reaction
Arrhenius	An Arrhenius acid will dissociate to produce a hydrogen ion (H^+)	An Arrhenius base will dissociate to produce a hydroxide ion (OH^-)	$HCl \rightarrow H^+ + Cl^-$ The Arrhenius acid, hydrochloric acid dissociates to produce H^+ $NaOH \rightarrow Na^+ + OH^-$ The Arrhenius base, sodium hydroxide dissociates to produce OH^-
Bronsted-Lowry	A Bronsted-Lowry acid is a *proton donor*	A Bronsted-Lowry base is a *proton acceptor*	$HC_2H_3O_2 + H_2O \rightleftharpoons C_2H_3O_2^- + H_3O^+$ The Bronsted-Lowry acid, acetic acid ($HC_2H_3O_2$) donates a proton to water. $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ The Bronsted-Lowry base, ammonia (NH_3) accepts a proton from water.
Lewis	A Lewis acid is an *electron acceptor*	A Lewis base is an *electron donor (will donate an unshared electron pair)*	$BF_3 + NH_3 \rightarrow BF_3NH_3$  The unshared electron pair of NH_3 is donated to the electron deficient molecule BF_3, forming a bond. The NH_3 is the electron donor and is therefore a Lewis base; the BF_3 is the electron acceptor and is therefore a Lewis acid.