# Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# States of Matter and Solutions Test

**Multiple Choice (2 points each)**

1. Ionic compounds in the solid state at room temperature are generally characterized by their

(A) ability to conduct an electric current.

(B) high vapor pressures.

(C) solubility in polar solvents.

(D) solubility in nonpolar solvents.

1. low melting points.

2. For a solvent to promote the ionization of compounds, the most essential characteristic of the solvent would be for it to

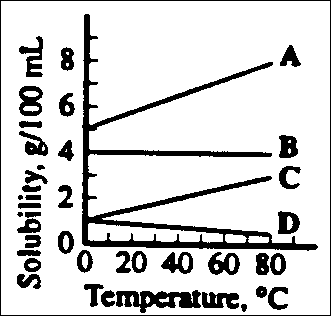
(A) exist as a liquid at room conditions.

(B) have a high dipole moment.

(C) have a low dielectric constant.

(D) be a good conductor of electricity.

1. have a high density.



3. The aqueous solubilities of several compounds between temperatures of 0 °C and 80 °C are shown in this diagram. Which compound can be recovered with the highest percent yield by dissolving a sample in water at 80 °C and cooling to 0 °C?

(A) A  
(B) B  
(C) C  
(D) D

4. Which is the ***best*** electrical conductor?

(A) 0.1 M KCl

(B) 0.1 M HC2H3O2

(C) 0.1 M MgSO4

(D) 0.1 M MgCl2

5. What is the molality of 7.80% by weight glucose (C6H12O6 molar mass = 180.16 g/mol) solution?

(A) 0.470 m

(B) 0.0454 m

(C) 0.845 m

(D) 0.0844 m

(E) 0.0432 m

6. If the pressure of a gas over a liquid increases, the amount of gas dissolved in the liquid will

(A) increase

(B) decrease

(C) remain the same

(D) have a higher vapor pressure

(E) depends on the polarity of the gas

7. Which of the following solutions would have the lowest vapor pressure?

(A) 1 *m* glucose (C6H12O6)

(B) 1 *m* MgCl2

(C) 1 *m* NaBr

(D) 1 *m* NaNO3

(E) pure H2O

8. You need a solution that is 0.15 *m* in ions. How many grams of MgCl2 (molar mass = 95.2 g/mol) must you dissolve in 400. g of water? (Assume total dissociation of the ionic salt.)

(A) 0.060 g

(B) 7.6 g

(C) 1.9 g

(D) 17 g

(E) 5.7 g

9. Which conditions favor the high solubility of a gas in a liquid?

(A) high pressure, high temperature

(B) high pressure, low temperature

(C) low pressure, high temperature

(D) low pressure, low temperature

10. Which factor is of major importance in limiting the solubility of alumina, Al2O3, in water?

(A) the small solvation energy of the aluminum(III) ion

(B) the large lattice energy of alumina

(C) the large ionization potential of aluminum

1. the relatively large sublimation energy of aluminum

11. The addition of a non-volatile solute to water will always

(A) increase the boiling point.

(B) increase the freezing point.

(C) increase the temperature of the solution.

(D) increase the vapor pressure at a specific temperature.

1. increase the total volume relative to the sum of the volumes of the components.

12. Mercury(II) chloride is much more soluble in benzene (nonpolar) than is magnesium chloride. This is because

(A) mercury(II) chloride is more covalent than magnesium chloride.

(B) mercury is more active than magnesium.

(C) magnesium is more active than mercury.

(D) magnesium chloride forms hydrates.

1. water is an ionic compound.

13. The equilibrium vapor pressure of a solution is dependent on

(A) the temperature only.

(B) the temperature and mole fraction of the solution.

(C) the volume and temperature of the solution

(D) the surface area and mole fraction of the solution

14. A mixture of 100 g of K2Cr2O7 and 200 g of water is stirred at 60 °C until no more of this salt dissolves. The resulting solution is decanted (poured off) and cooled to 20 °C. What mass of K2Cr2O7 crystallizes from the solution during the cooling?



(A) 24 g

(B) 31 g

(C) 43 g

(D) 62 g

(E) 86 g

15. The mass of 560 cm3 (STP) of an unknown gas is 1.60 g. This gas could be

Molar Masses

CO2 44.  g·mol–1 Cl2 71.  g·mol–1

O2 32.  g·mol–1 SO2 64.  g·mol–1

(A) oxygen.

(B) carbon dioxide.

(C) chlorine.

(D) sulfur dioxide.

16. Which has the highest molar heat of vaporization?

(A) a molecular liquid, S8

(B) a hydrogen-bonded liquid, H2O

1. a monatomic liquid, Ar
2. an ionic melt, BaF2

17. Arrange KCl, NH3, and CH4 in order of increasing boiling point.

(A) CH4<KCl<NH3

(B) CH4<NH3<KCl

(C) NH3<KCl<CH4

(D) NH3<CH4<KCl

18. The height of the mercury in the right arm open to atmospheric pressure (760 mmHg) is 100 mm and the height in the left arm is 120 mm.



What is the pressure of the gas in the bulb?

(A) 20 mmHg

(B) 640 mmHg

(C) 740 mmHg

(D) 780 mmHg

19. The critical temperature of H2O is higher than that of N2, because H2O

(A) has a higher dissociation energy.

(B) has a lower molecular weight.

(C) has weaker intermolecular bonds.

(D) has two covalent bonds.

1. is capable of hydrogen bonding.

20. The pressure exerted by a gas is inversely proportional to the volume it occupies. Which is the best ***experimental*** evidence for this?

(A) When the space in which the gas molecules move is halved, the number of collisions they make with the walls per second is doubled.

(B) A gas always completely fills its container.

1. If the pressure on a sample of gas is doubled, the gas is compressed to half

its original volume.

(D) Gas molecules travel in straight lines at high speed.

(E) The sum of the partial pressures of the gases in a mixture is equal to the total pressure of the mixture.

21. At the melting point of ice, 0 °C at 1 atm pressure,

(A) no heat is required to melt ice.

(B) the vapor pressure of ice is greater than the vapor pressure of liquid water.

(C) water cannot freeze.

(D) the solid and liquid states of water can coexist.

(E) a piece of ice in a thermos bottle turns to water.

22. Which of the following statements about gases is false?

|  |  |
| --- | --- |
| A) | Gases are highly compressible. |
| B) | Distances between molecules of gas are very large compared to bond distances within molecules. |
| C) | Non-reacting gas mixtures are homogeneous. |
| D) | Gases expand spontaneously to fill the container they are placed in. |
| E) | All gases are colorless and odorless at room temperature. |

23. Consider the phase diagram of a pure compound. Which statement applies?



(A) The path **A** **C** represents sublimation.

1. Following the path **A** **B** **C** the compound would first liquefy and then vaporize.
2. If the compound is in state **A**, continued reduction of the pressure (at constant temperature) will cause it to melt.
3. None of these statements is correct.

24. Which point represents a liquid-vapor equilibrium in this phase diagram?



(A) **A**

(B) **B**

(C) **C**

(D) **D**

25. "Isothermal" means \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | at constant pressure |
| B) | at constant temperature |
| C) | at variable temperature and pressure conditions |
| D) | at ideal temperature and pressure conditions |
| E) | that |

26. Standard temperature and pressure (STP), in the context of gases, refers to \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | 298.15 K and 1 atm |
| B) | 273.15 K and 1 atm |
| C) | 298.15 K and 1 torr |
| D) | 273.15 K and 1 pascal |
| E) | 273.15 K and 1 torr |

27. 10.0 grams of argon and 20.0 grams of neon are placed in a 1200.0 ml container at 25.0°C. The partial pressure of neon is \_\_\_\_\_\_\_\_\_\_ atm.

|  |  |
| --- | --- |
| A) | 20.4 |
| B) | 8.70 |
| C) | 0.700 |
| D) | 3.40 |
| E) | 5.60 |

28. The average kinetic energy of the particles of a gas is directly proportional to \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | the rms speed |
| B) | the square of the rms speed |
| C) | the square root of the rms speed |
| D) | the square of the particle mass |
| E) | the particle mass |

29. Of the following gases, \_\_\_\_\_\_\_\_\_\_ will have the greatest rate of effusion at a given temperature.

|  |  |
| --- | --- |
| A) | NH3 |
| B) | CH4 |
| C) | Ar |
| D) | HBr |
| E) | HCl |

30. At STP, the ratio of the root-mean-square speed of CO2 to that of SO2 is \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | 2.001 |
| B) | 2.119 |
| C) | 1.000 |
| D) | 1.207 |
| E) | 1.456 |

31. Arrange the following gases in order of increasing average molecular speed at 25°C.

He, O2, CO2, N2

|  |  |
| --- | --- |
| A) | He < N2 < O2 < CO2 |
| B) | He < O2 < N2 < CO2 |
| C) | CO2 < O2 < N2 < He |
| D) | CO2 < N2 < O2 < He |
| E) | CO2 < He < N2 < O2 |

32. An ideal gas differs from a real gas in that the molecules of an ideal gas \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | have no attraction for one another |
| B) | have appreciable molecular volumes |
| C) | have a molecular weight of zero |
| D) | have no kinetic energy |
| E) | have an average molecular mass |

33. The van der Waals equation for real gases recognizes that \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | gas particles have non-zero volumes and interact with each other |
| B) | molar volumes of gases of different types are different |
| C) | the non-zero volumes of gas particles effectively decrease the amount of "empty space" between them |
| D) | the molecular attractions between particles of gas decreases the pressure exerted by the gas |
| E) | all of the above statements are true |

34. When gases are treated as real, via use of the van der Waals equation, the actual volume occupied by gas molecules \_\_\_\_\_\_\_\_\_\_ the pressure exerted and the attractive forces between gas molecules \_\_\_\_\_\_\_\_\_\_ the pressure exerted, as compared to an ideal gas.

|  |  |
| --- | --- |
| A) | decreases, increases |
| B) | increases, increases |
| C) | increases, decreases |
| D) | does not affect, decreases |
| E) | does not affect, increases |

35. Crystalline solids \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | have their particles arranged randomly |
| B) | have highly ordered structures |
| C) | are usually very soft |
| D) | exist only at high temperatures |
| E) | exist only at very low temperatures |

36. In liquids, the attractive intermolecular forces are \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | very weak compared with kinetic energies of the molecules |
| B) | strong enough to hold molecules relatively close together |
| C) | strong enough to keep the molecules confined to vibrating about their fixed lattice points |
| D) | not strong enough to keep molecules from moving past each other |
| E) | strong enough to hold molecules relatively close together but not strong enough to keep molecules from moving past each other |

37. Of the following substances, only \_\_\_\_\_\_\_\_\_\_ has London dispersion forces as its only intermolecular force.

|  |  |
| --- | --- |
| A) | CH3OH |
| B) | NH3 |
| C) | H2S |
| D) | CH4 |
| E) | HCl |

38. In which of the following molecules is hydrogen bonding likely to be the most significant component of the total intermolecular forces?

|  |  |
| --- | --- |
| A) | CH4 |
| B) | C5H11OH |
| C) | C6H13NH2 |
| D) | CH3OH |
| E) | CO2 |

39. Elemental iodine (I2) is a solid at room temperature. What is the major attractive force that exists among different I2 molecules in the solid?

|  |  |
| --- | --- |
| A) | London dispersion forces |
| B) | dipole-dipole rejections |
| C) | ionic-dipole interactions |
| D) | covalent-ionic interactions |
| E) | dipole-dipole attractions |

40. Hydrogen bonding is a special case of \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | London-dispersion forces |
| B) | ion-dipole attraction |
| C) | dipole-dipole attractions |
| D) | ion-ion interactions |
| E) | none of the above |

41. \_\_\_\_\_\_\_\_\_\_ is the energy required to expand the surface area of a liquid by a unit amount of area.

|  |  |
| --- | --- |
| A) | Viscosity |
| B) | Surface tension |
| C) | Volatility |
| D) | Meniscus |
| E) | Capillary action |

42. Which statements about viscosity are true?

(i) Viscosity increases as temperature decreases.

(ii) Viscosity increases as molecular weight increases.

(iii) Viscosity increases as intermolecular forces increase.

|  |  |
| --- | --- |
| A) | (i) only |
| B) | (ii) and (iii) |
| C) | (i) and (iii) |
| D) | none |
| E) | all |

43. The shape of a liquid's meniscus is determined by \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | the viscosity of the liquid |
| B) | the type of material the container is made of |
| C) | the relative magnitudes of cohesive forces in the liquid and adhesive forces between the liquid and its container |
| D) | the amount of hydrogen bonding in the liquid |
| E) | the volume of the liquid |

44. Which of the following statements is false?

|  |  |
| --- | --- |
| A) | The absolute value of the heat of sublimation is equal to the absolute value of the heat of deposition. |
| B) | The heat of sublimation is equal to the sum of the heat of vaporization and the heat of melting. |
| C) | The heat of sublimation is equal to the sum of the heat of vaporization and the heat of freezing. |
| D) | The absolute value of the heat of sublimation is equal to the absolute value of the sum of the heat of condensation and the heat of freezing. |
| E) | The absolute value of the heat of deposition is equal to sum of the absolute value of the heat of vaporization and the absolute value of the heat of freezing. |

45. Of the following, \_\_\_\_\_\_\_\_\_\_ is an exothermic process.

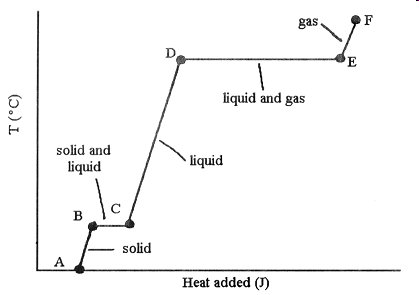
|  |  |
| --- | --- |
| A) | melting |
| B) | subliming |
| C) | freezing |
| D) | boiling |
| E) | All of the above are exothermic. |

46. Some things take longer to cook at high altitudes than at low altitudes because \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | water boils at a lower temperature at high altitude than at low altitude |
| B) | water boils at a higher temperature at high altitude than at low altitude |
| C) | heat isn't conducted as well in low density air |
| D) | natural gas flames don't burn as hot at high altitudes |
| E) | there is a higher moisture content in the air at high altitude |

47. A solid has a very high melting point, great hardness, and poor electrical conduction. This is a(n) \_\_\_\_\_\_\_\_\_\_ solid.

|  |  |
| --- | --- |
| A) | ionic |
| B) | molecular |
| C) | metallic |
| D) | covalent network |
| E) | metallic and covalent network |



48. The phase changes B  C and D  E are not associated with temperature increases because the heat energy is used up to \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | increase distances between molecules |
| B) | break intramolecular bonds |
| C) | rearrange atoms within molecules |
| D) | increase the velocity of molecules |
| E) | increase the density of the sample |

49. An alloy is a

|  |  |
| --- | --- |
| A) | heterogeneous mixture of two metals. |
| B) | pure metal. |
| C) | metallic material that is composed of two or more elements. |
| D) | nonmetal with some properties of a metal. |
| E) | a mineral containing two or more metals. |

50. What is the typical effect of the addition of an interstitial element on the properties of a metal?

|  |  |
| --- | --- |
| A) | increase in malleability and corrosion resistance |
| B) | increase in hardness and strength, decrease in ductility |
| C) | decrease in melting point and increase in ductility |
| D) | decrease in conductivity and increase in brittleness |
| E) | increased surface luster |

AP Question #1

(a) Calculate the molality of a 20.0 percent by weight aqueous solution of NH4Cl. (MW: NH4Cl = 53.5)

1. If this NH4Cl solution is assumed to be ideal and is completely dissociated into ions, calculate the vapor pressure of this solution at 29.0C. (water vapor @29C = 28.8 mmHg)
2. Actually a solution of NH4Cl of this concentration is not ideal. Explain why?

AP Question #2

(d) Two types of intermolecular forces present in liquid H2S are London (dispersion) forces and dipole-dipole

forces.

(i) Compare the strength of the London (dispersion) forces in liquid H2S to the strength of the London

(dispersion) forces in liquid H2O. Explain.

(ii) Compare the strength of the dipole-dipole forces in liquid H2S to the strength of the dipole-dipole

forces in liquid H2O. Explain.

AP Question #3

A sample of a pure, gaseous hydrocarbon is introduced into a previously evacuated rigid 1.00 L vessel. The

pressure of the gas is 0.200 atm at a temperature of 127°C.

(a) Calculate the number of moles of the hydrocarbon in the vessel.

(b) O2(*g*) is introduced into the same vessel containing the hydrocarbon. After the addition of the O2(*g*), the

total pressure of the gas mixture in the vessel is 1.40 atm at 127. Calculate the partial pressure of O2(*g*) in

the vessel.

AP Question #4

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CO2 O2 He Xe CH4

Represented above are five identical balloons, each filed to the same volume at 25 °C and 1.0 atmosphere pressure with the pure gases indicated.

1. Which balloon contains the greatest mass? Explain
2. Compare the average kinetic energies of the gas molecules in the balloons. Explain.
3. Which balloon contains the gas that would be expected to deviate most from the behavior of an ideal gas? Explain
4. Twelve hours after being filled, all the balloons have decreased in size. Predict which balloon will be the smallest. Explain your reasoning.

# Short Answer

4. **Consider the following solutions:**

0.010 m Na3PO4 in water 0.020 m CaBr2 in water

0.020 m KCl in water 0.020 m HF in water (HF is a weak acid)

## Explain your answers

1. Assuming complete dissociation of the soluble salts, which solution (s) would have the same Boiling point as 0.040 m Glucose (C6H12O6) in water (glucose is a non-electrolyte) **4 pts**
2. Which solution would have the highest vapor pressure at 28°C? **3 pts**
3. Which solution would have the highest freezing point depression? **3 pts**

5. An important process for the production of acrylonitrile (C3H3N) is given by the following reaction:

2C3H6(g) + 2NH3(g) + 3O2(g) → 2 C3H3N (g) +6H2O (g)

A 150. L reactor is charged to the following partial pressures at 25 °C:

PC3H6 = 0.500 MPa

P NH3 = 0.800 MPa

PO2 = 1.500 Mpa

1. What is the total pressure in the container? **(3 points)**
2. What is the mass of acrylonitrile can be produced form this mixture ? **(5 points)**

(MPa = 106 Pa) (101.3Kpa = 1.0 atm)

6. How much energy does it take to heat 130.0 g of ice at –40.0 ° C to steam at 160.0 °C? **(5 points)**

ΔHvap = 43.9 kJ/mol ΔHfus = 6.00 kJ/mol

Cp ice = 2.10 J/g K Cp water = 4.18 J/g K Cp steam = 1.8J/g K

1976 B Answer:

(a) 



(b) P1 = (P)(*X*1)

mol ions = (2)(4.67 mol) = 9.34 mol

1 kg water = 55.6 mol water



P1= (29.8 mm Hg)(0.856) = 25.5 mm Hg

(c) Assume no dissociation.

T = kf*m* = (1.86)(4.67) = 8.69C

i = 15.3 / 8.69 = 1.76

(1.76 - 1.00)(100) = 76% dissociated

Answer:

(a) Tf = kf*m*; 0.97C = (1.86C*m*-1)(*m*)

m = 0.52 mol solute/kg solvent

In this solution, 3.23 g solute in 100.0 g water or 32.3 g solute in 1 kg of water



(b) 





= C2H6O2

(c) 2 C2H6O2 + 5 O2  6 H2O*(g)* + 4 CO2*(g)*



= 0.0847 mol gas

P = (nRT) / V



1975 D

Answer:

An alcohol-water solution has a higher than normal (pure water) vapor pressure because alcohol is a volatile solute and contributes substantially to the vapor of the solution. The higher the vapor pressure, the lower the boiling point. A salt-water solution has a lower than normal vapor because salt is a non-volatile solute and solute-solvent interaction decrease the vapor of the solution, the lower the vapor pressure, the higher the boiling point.

Answer 2005:

(a) (i) 1.9061 g  = 0.5198 g of C

0.3370 g H2O  = 0.03744 g of H

0.7549 g sample

–0.5198 g C

–0.0374 g H

0.1977 g of Oxygen

(ii) 0.5198 g C  = 43.32 mmol C

0.0374 g H  = 37.4 mmol H

0.1977 g O  = 12.36 mmol O

dividing each by 12.36 gives

3.5 C : 3 H : 1 Oxygen, OR 7 C : 6 H : 2 O, thus an empirical formula of C7H6O2

(b) (i) molality = = = 0.431 *m*

(ii) molar mass = = = 122 g/mol

(c) from (a)(ii), the molar mass of C7H6O2 = 122.0 g/mol

since the two molar mass are the same, the empirical formula = molecular formula

(d) low pH indicates an organic acid containing the carboxyl functional group, –COOH.

[likely benzoic acid]