MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Consider the following reversible reaction:

$$POCl_3(g) \rightleftharpoons POCl(g) + Cl_2(g) \qquad K_c = 0.450$$

The following initial amounts of reactants and products were mixed: $[POCl_3] = 0.750$ M, $[POCl] = 0.550$ M, and $[Cl_2] = 0.150$ M. What is the equilibrium concentration of POCl?

A) 0.945 M
B) 0.360 M
C) 0.155 M
D) 0.395 M
E) 0.740 M

2) Determine the equilibrium $[F^-]$ of the following solution with initial concentrations of $[HF] = 1.296$ M, $[NaF] = 1.045$ M. (K_a for HF is 6.6×10^{-4})

A) 1.046
B) 0.251
C) 2.344
D) 8.2×10^{-4}
E) 5.3×10^{-4}

3) If $\Delta G < 0$ for a reaction, then the reaction is said to be:

A) reversible
B) endothermic
C) exothermic
D) spontaneous
E) none of these

Enter All Answers in the Scantron Sheets

4) The aqueous solubility of carbon monoxide at 0.0 °C and 1.0 atm CO pressure is 0.0354 mg CO per mL of solution. What would be the molarity of CO in water at 0.0 °C and the observed partial pressure of CO in air (0.00036 atm)?

A) 1.6×10^{-3} M
B) 4.5×10^{-7} M
C) 1.3×10^{-5} M
D) 3.2×10^{-3} M
E) 2.9×10^{-4} M

$S = 0.0354 = M = 0.054$

$P = \frac{nRT}{V}$ $\frac{n}{VM}$

5) Which of the following ionic compounds should have the highest melting point?

A) KF
B) NaI
C) NaCl
D) LiBr
E) MgO

6) What is the percent yield if 122 grams of SiO_2 (s) are made from 246 g of Cr_2O_3 (s) and 4.00 kg of Si (s) by the following equation?

$3\,Si(s) + 2\,Cr_2O_3(s) \rightarrow 3\,SiO_2(s) + 4\,Cr(l)$

A) 83.6%
B) 125%
C) 33.1%
D) 49.6%
E) 59.3%

$\frac{3 \times (28.09)}{4000g} + \frac{2(152)}{246} \longrightarrow \frac{3(60.09)}{122.8g} + 4(5$

$84.27 + 304 \longrightarrow 180.27 + 2$

$\frac{246}{122}$ 150.75

7) A 1.00 molal solution of NaCl in water contains:

$\frac{0.59}{kg}$

A) 1.00 mol NaCl per 1000.0 kg H_2O
B) 1.00 g NaCl per 1000.0 g H_2O
C) 1.00 mol NaCl per 1000.0 mol H_2O
D) 1000.0 g NaCl per 1000.0 g H_2O
E) 1.00 mol NaCl per 1000.0 g H_2O

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B) 1.00 g NaCl per 1000.0 g H_2O
C) 1.00 mol NaCl per 1000.0 mol H_2O
D) 1000.0 g NaCl per 1000.0 g H_2O
E) 1.00 mol NaCl per 1000.0 g H_2O

Enter All Answers in the Scantron Sheets

8) For a first order reaction with a half-life of 1.25 hours, what is the value of k?

A) 1.54×10^{-4} min^{-1}
B) 2.67×10^{-2} min^{-1}
C) 9.24×10^{-3} min^{-1}
D) 1.33×10^{-2} min^{-1}
E) 52.0 min^{-1}

$t = \frac{\ln 2}{K}$

9) For the reaction: $2A(g) \rightarrow 2B(g) + C(g)$ concentration – time data are:

t(s)	[A]	ln[A]	$\frac{1}{[A]}$
0.00	2.000	.300	.500
0.40	1.467	.166	.682
0.80	1.076	.032	.929
1.20	.789	-.103	1.267
1.60	.579	-.237	1.727
2.00	.424	-.373	2.358

What is the order of the reaction with respect to [A]?

A) zero
B) second
C) third
D) first
E) none of these

10) For the reaction: $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$ at the time when N_2O_5 is being consumed at a rate of -1.2×10^{-4} M/s, what is the rate at which O_2 is being formed?

A) 2.4×10^{-4} M/s
B) 6.0×10^{-5} M/s
C) 4.8×10^{-4} M/s
D) 1.2×10^{-4} M/s
E) 3.0×10^{-5} M/s

$K_p = \frac{P^4 \cdot P}{P^2}$

Enter All Answers in the Scantron Sheets

11) A 10.0 g sample of bismuth tribromide, $BiBr_3$, contains:

A) 3.14×10^{22} formula units $BiBr_3$
B) 0.322 mol $BiBr_3$
✓ C) 5.37×10^{22} total number of atoms
D) 4.02×10^{22} total number of atoms
E) 1.34×10^{22} bromide ions

12) Which of the following processes would NOT result in an increase in entropy?

A) a glass of cool lemonade warming in the sun
B) melting of an ice cube
C) evaporation of a puddle of gasoline
✓ D) condensation of water vapor on a cold windshield
E) sublimation of a dry ice

13) How many coulombs would be needed to deposit all of the Ag^+ ion from 600 mL of a solution 0.250 M in Ag^+?

A) 1.56×10^6 C
B) 1.56×10^4 C
C) 2.41×10^4 C
✓ D) 1.45×10^7 C
E) 1.45×10^4 C

14) When the following equation is completed and balanced for the reaction in acidic solution, what is the proper coefficient for H^+?

$$Zn(s) + Cr_2O_7^{2-}(aq) \rightarrow Zn^{2+}(aq) + Cr^{2+}(aq)$$

A) 18
B) 22
C) 7
D) 11
— E) 14

Enter All Answers in the Scantron Sheets

15) What is the rate law for the following mechanism?

$CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOC_2H_6^+ + OH^-$ (Slow)

$CH_3COOC_2H_6^+ \rightarrow CH_3COOH + C_2H_5^+$ (Very Fast)

$C_2H_5^+ + OH^- \rightarrow C_2H_5OH$ (Fast)

A) Rate = $k[CH_3COOC_2H_5]$

✓ B) Rate = $k[CH_3COOC_2H_5][H_2O]$

C) Rate = $k[CH_3COOH]$

D) Rate = $k[CH_3COOC_2H_5][H_2O]^2$

E) Rate = $k[C_2H_5OH]$

16) Given:

$2\ LiOH(s) \rightarrow Li_2O(s) + H_2O(l)$ $\Delta H° = +379.1$ kJ

$LiH(s) + H_2O(l) \rightarrow LiOH(s) + H_2(g)$ $\Delta H° = -111.0$ kJ

$2\ H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$ $\Delta H° = +285.9$ kJ

Compute $\Delta H°$ in kJ for $2\ LiH(s) + O_2(g) \rightarrow Li_2O(s) + H_2O(l)$

A) -303.6

B) +554.0

C) -128.8

D) +443.0

E) none of these

17) White phosphorus, P_4, spontaneously bursts into flame in oxygen gas. If 6.500 g of white phosphorus reacts completely with oxygen to form 11.54 g of a phosphorus oxide, what is the empirical formula of this oxide?

✓A) P_2O_3

B) PO_3

C) P_2O_6

D) P_4O_6

E) None of the above.

6.5 g

$P_3 + O_2 \longrightarrow P_2O_3$

6.5 11.54

$11.54 - 6.5 = 4.96$ gr O_2

$n_{O_2} = \frac{5.04}{32} = 0.1575$

$n_{P_4} = \frac{6.5}{124} = 0.052$

P O

0.052 0.1575

1 3

Enter All Answers in the Scantron Sheets

18) When a liquid is in equilibrium with its vapor in a closed container:

A) the rate at which molecules from the liquid phase enter the gas phase exactly equals the rate at which molecules from the gas phase pass into the liquid phase
B) the amount of gas in the container must exactly equal the amount of liquid
C) a change in temperature will not change the pressure in the container
D) molecules cannot go from the liquid phase to the gas phase because the amount of liquid in the container is constant
E) the vapor will gradually change back to the liquid state, that is, no vapor will be left

19) Which of the following is longest?

A) 3.0×10^{-10} cm
B) 300 pm
C) 3.0×10^{-14} m
D) 3.0 nm
E) All values are the same length

20) 0.750 mol of N_2 and 1.200 mol of H_2 are placed in a 3.00 liter container. When the reaction:
$N_2(g) + 3H_2(g) \rightleftharpoons 2\,NH_3(g)$ reaches equilibrium, $[H_2] = 0.100$ M. Which of the following is true?

A) $[NH_3] = 0.150$ M
B) $[NH_3] = 0.200$ M
C) $[N_2] = 0.250$ M
D) $[N_2] = 0.650$ M
E) none of these

21) Which of the following substances under equal conditions and in the same phase has the greatest molar entropy?

A) NO_2
B) N_2O_3
C) N_2O_5
D) NO
E) N_2O_4

Enter All Answers in the Scantron Sheets

22) Given that:

$Ag^+(aq) + e^- \rightarrow Ag(s)$ $\quad E° = 0.800$ V ;

$Mg^{2+}(aq) + 2\,e^- \rightarrow Mg(s)$ $\quad E° = -2.356$ V ;

is the following reaction spontaneous and why?

$$Mg(s) + 2\,AgNO_3(aq) \rightarrow 2\,Ag(s) + Mg(NO_3)_2(aq)$$

A) no, $E°$ is a positive value
B) yes, $E°$ is a negative value
C) no, $E°$ is a negative value
D) yes, $E°$ is a positive value
E) no, Mg(s) does not react with Ag^+

23) What is the reaction for the standard enthalpy of formation for HCl(g)?

A) $NH_3(g) + Cl_2(g) \rightarrow NH_2Cl(g) + HCl(g)$
B) $0.5\,H_2(g) + Cl_2(g) \rightarrow HCl(g)$
C) $H^+(aq) + Cl^-(aq) \rightarrow HCl(g)$
D) $ICl_3(g) + 2\,H_3(g) \rightarrow HI(g) + 3\,HCl(g)$
E) none of these

24) The substance NH_3 ($K_b = 5.6 \times 10^{-10}$) in water solution is a:

A) strong base
B) weak electrolyte
C) buffer
D) strong electrolyte
E) nonelectrolyte

Enter All Answers in the Scantron Sheets

25) Calculate ΔG for the reaction $Cu(s) + H_2O(g) \rightarrow CuO(s) + H_2(g)$ at 500K.

	ΔH_f (kJ/mol)	S (J/mol K)
Cu(s)		33.3
$H_2O(g)$	-241.8	188.7
CuO(s)	-155.2	43.5
$H_2(g)$		130.6

A) 110.6 kJ
B) -58.6 kJ
C) -135.4 kJ
D) 231.8 kJ
E) 86.74 kJ

$\Delta H = -155.2 + 241.8 = 86.6$ kJ

$\Delta G = \Delta S = (130 + 43.5) - (188.7 + 333)$

$= 173.5 - 222 = -48.5$

$\Delta G = 86600 + (500 \times 48.5) = 110850$

$= 110.6$ kJ

26) Data for the reaction A + B → C are given below. Find the rate constant for this system.

Experiment	[A], M	[B], M	Initial rate, M/s
1	0.030	0.060	2.5×10^{-5}
2	0.030	0.020	2.5×10^{-5}
3	0.060	0.060	10.0×10^{-5}

A) $2.8 \times 10^{-2}\ M^{-1}\ s^{-1}$
B) $1.7 \times 10^{-3}\ M\ s^{-1}$
C) $2.8 \times 10^{-2}\ M\ s^{-1}$
D) $2.8 \times 10^{-2}\ M^{2}\ s^{-1}$
E) $1.7 \times 10^{-3}\ M^{-1}\ s^{-1}$

27) Given that the vapor pressure of pure n-hexane and pure n-heptane at 25 °C are 151.4 mmHg and 45.62 mmHg respectively, calculate the total vapor pressure above a solution at 25 °C containing only n-hexane and n-heptane in which the mole fraction of n-hexane is 0.600.

A) 197 mmHg
B) 90.8 mmHg
C) 109 mmHg
D) 118 mmHg
E) 106 mmHg

$P_0 = 197$

$T = 298$

0.600

$P = \chi_1 P_1^0$

r All Answers in the Scantron Sheets

28) To precipitate Ag^+ from solution one could add:

A) $(NH_4)_2CO_3(aq)$ in $NH_3(aq)$
B) $KOH(aq)$
C) $NaNO_3(aq)$
D) $HNO_3(aq)$
E) $CaCl_2(aq)$

29) For $CO(g) + H_2(g) \rightleftharpoons H_2CO(g)$, $\Delta H° = -5.36$ kJ/mol and $\Delta S° = -109.8$ J/(mol°K). Assuming that the values of $\Delta H°$ and $\Delta S°$ do not vary with temperature, what is the temperature at which K_{eq} is 1.0×10^{-2}?

A) 25 °C
B) -237 °C
C) 412 °C
D) -198 °C
E) 218 °C

30) The first-order reaction A → Products has a half-life, $t_{1/2}$, of 55.0 min at 25 °C and 6.8 min at 100 °C. What is the activation energy for this reaction?

A) 38.8 kJ/mol
B) 347 kJ/mol
C) 25.8 kJ/mol
D) -38.8 kJ/mol
E) -25.8 kJ/mol

31) A solution of an unknown acid had a pH of 3.70. Titration of a 25.0 mL aliquot of the acid solution required 21.7 mL of 0.104 M sodium hydroxide for complete reaction. Assuming that the acid is monoprotic, what is its ionization constant?

A) 3.6×10^{-9}
B) 2.0×10^{-4}
C) 2.7×10^{-11}
D) 4.4×10^{-7}
E) 9.0×10^{-2}

Enter All Answers in the Scantron Sheets

32) A solution of potassium permanganate was standardized by titration of a solution prepared by dissolving 0.268 g of pure sodium oxalate in approximately 25 mL of distilled water. A 31.4 mL volume of titrant was required to reach the endpoint. The reaction is:

$$2\,MnO_4^- + 5\,C_2O_4^{2-} + 16\,H^+ \rightarrow 2\,Mn^{2+} + 10\,CO_2 + 8\,H_2O.$$

What is the initial molarity of MnO_4^- in solution?

A) 0.0174 M
B) 0.0255 M
C) 0.0348 M
D) 0.159 M
E) 0.0637 M

33) A 500.0 mL sample of $O_2(g)$ is at 780 mmHg and 30 °C. What will be the new volume if, with constant pressure and amount of gas, the temperature is decreased to -15 °C?

A) 437 mL
B) 500 mL
C) 250 mL
D) 587 mL
E) 426 mL

$\frac{V_f}{T_f} = \frac{V_i}{T_i}$ $T = 303\,K$ $\Rightarrow \frac{P_1V_1 = nRT_1}{P_2V_2 = nRT_2}$

$V_i = 0.5$

$P_1 = 1.02$

$T_2 = +258\,K$

34) How long would it take to deposit 15.0 g of copper metal from a copper (II) sulfate solution using an electrolysis cell running with a current of 150 mA ? (1 A = 1 C/sec)

A) 19.0 h
B) 42.2 h
C) 12.7 h
D) 4.22 h
E) 84.4 h

$n = \frac{I}{}$ I $T \neq$

$= \frac{0.15\,A\,t}{9.65 \times 10^4}$ $n = \frac{I\,E}{F}$

Enter All Answers in the Scantron Sheets

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34) How long would it take to deposit 15.0 g of copper metal from a copper (II) sulfate solution using an electrolysis cell running with a current of 150 mA ? (1 A = 1 C/sec)

A) 19.0 h
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$n = \frac{I}{}$

I

$n = \frac{I t}{F}$

$= \frac{0.15\,A\,t}{9.65 \times 10^4}$

er All Answers in the Scantron Sheets

35) Which one of the four following compounds has the highest viscosity:
CH_3CH_2OH ; $CH_3CH_2CH_2CH_3$; $HOCH_2CH_2OH$; $CH_3OCH_2CH_3$?

A) $CH_3CH_2CH_2CH_3$
B) $CH_3OCH_2CH_3$
C) $HOCH_2CH_2OH$
D) CH_3CH_2OH
E) There is not enough information to determine relative viscosities.

36) The reaction A + B → C + D is second order in A and zero order in B. The value of *k* is 0.012 M^{-1} min^{-1}. What is the rate of this reaction when [A] = 0.125 M and [B] = 0.435 M?

A) 1.3 M min^{-1}
B) 1.9×10^{-4} M min^{-1}
C) 1.5×10^{-3} M min^{-1}
D) 5.0×10^{-4} M min^{-1}
E) 3.4×10^{-3} M min^{-1}

rate = $0.012[0.125]^2[0.435]^0$

37) When the equation $K_2S_2O_3 + I_2 \rightarrow K_2S_4O_6 + KI$ is balanced with the smallest integer coefficients, the coefficient of KI is:

A) 1
B) 2
C) 3
D) 4
E) 5

38) If one compares compound "A" composed of nonpolar molecules with compound "B" composed of polar molecules, and both molecules have the same molecular formula then it is true that:

A) "B" will not boil
B) "B" likely boils at a lower temperature than "A"
C) both compounds have the same boiling point
D) "A" will not boil
E) "A" likely boils at a lower temperature than "B"

Enter All Answers in the Scantron Sheets

39) The density of N_2O at 1.53 atm and 45.2°C is _____ g/L.

A) 9.99
B) 1.76
C) 18.2
D) 2.58
E) 0.388

40) Which of the following combinations of signs for ΔH and ΔS will <u>always</u> result in a reaction being nonspontaneous?

A) ΔH^-, ΔS^+
B) ΔH^+, ΔS^+
C) ΔH^-, ΔS^-
D) ΔH^+, ΔS^-
E) cannot determine without temperature

41) The reaction has the rate law Rate = $k[A][B]^2$. Which will cause the rate to increase the most?

A) tripling [B]
B) lowering temperature
C) quadrupling [A]
D) doubling [B]
E) doubling [A]

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The next question are based on the diagram below:

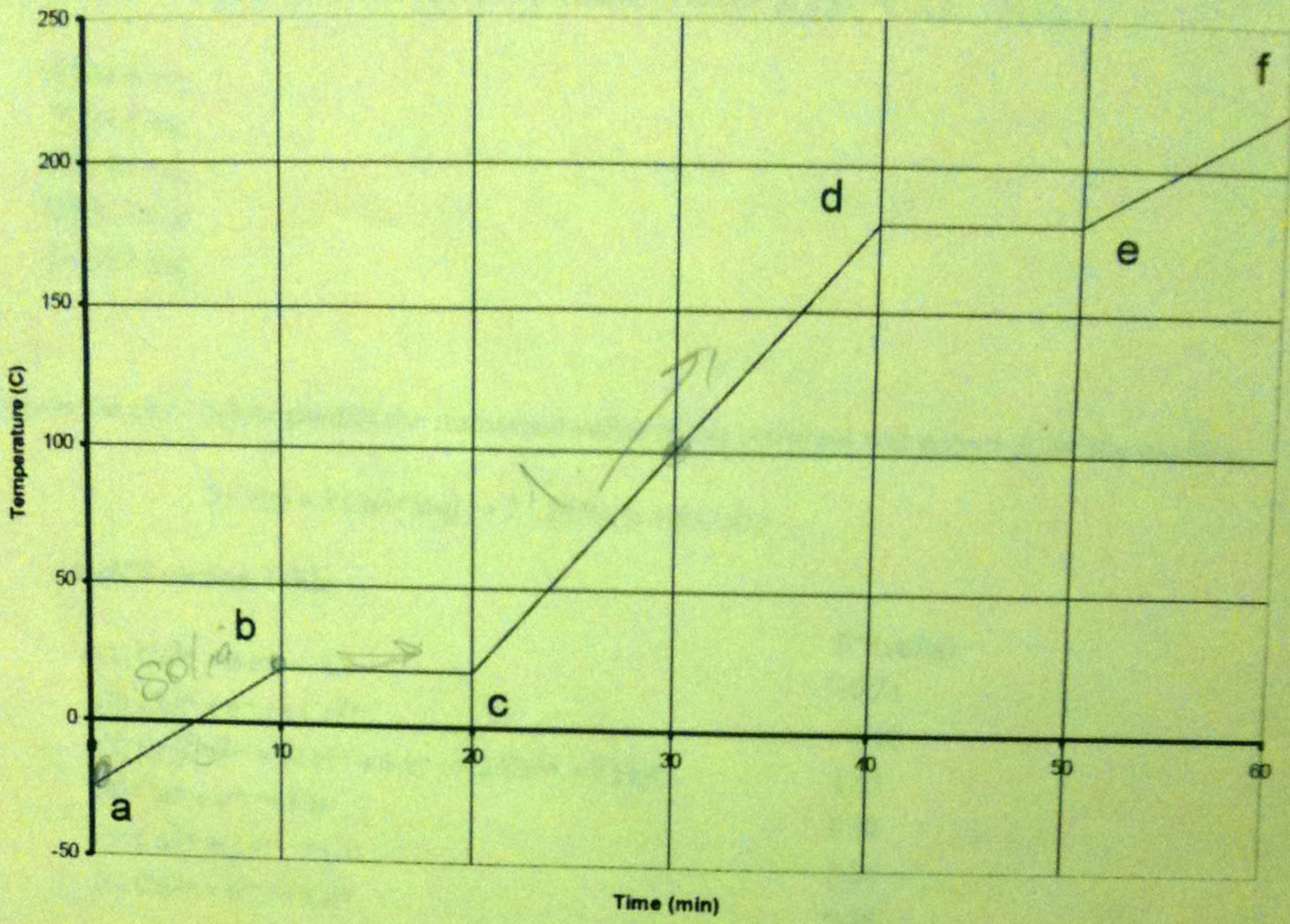

Figure 1. Heating curve for a hypothetical substance. A solid at point "a" is heated at a constant rate.

42) What phase of the material is present in the segment c–d in the figure?

A) Supercritical Fluid
B) Liquid
C) Gas
D) Solid
E) Face-Centered Cubic

43) From ammonia gas, one can obtain two different gases, each of which is a pure substance. Using only this information, it can be said with certainty that:

A) gases do not produce solids
B) ammonia cannot be an element
C) neither of the products can be an element
D) one of the products is an element
E) both products are elements

Enter All Answers in the Scantron Sheets

44) A 31.4 mL sample of N_2 gas was collected over water at 23.7 °C and a barometric pressure of 706 mmHg. What mass of N_2 was collected? [Vapor pressure of water at 23.7 °C is 22 mmHg].

A) 34.6 mg
B) 33.4 mg
C) 37.7 mg
D) 32.5 mg
E) 39.3 mg

V = 31 mL T = 23.7

706 =

45) Given the table below predict the numerical value of the standard cell potential for the reaction:

$$2\ Cr(s) + 3\ Cu^{2+}(aq) \rightarrow 2\ Cr^{3+}(aq) + 3\ Cu(s)$$

Half Reaction Table

	$E°$ (volts)
(1) $Cr^{3+} + 3\ e^- \rightarrow Cr$	-0.74
(2) $Cr^{3+} + e^- \rightarrow Cr^{2+}$	-0.41
(3) $Cr_2O_7^{2-} + 14\ H^+ + 6\ e^- \rightarrow 2\ Cr^{3+} + 7\ H_2O$	1.33
(4) $Cu^+ + e^- \rightarrow Cu$	0.52
(5) $Cu^{2+} + 2\ e^- \rightarrow Cu$	0.34
(6) $Cu^{2+} + e^- \rightarrow Cu^+$	0.16

A) -0.40 volts
B) 2.50 volts
C) 1.08 volts
D) 0.417 volts
E) -1.08 volts

46) For the cell shown below, which will increase the cell voltage the most?

$Fe^{2+} \mid Fe^{3+} \parallel Cu^{2+} \mid Cu$

A) Halve $[Cu^{2+}]$.
B) Double $[Cu^{2+}]$.
C) Double $[Fe^{2+}]$.
D) Halve $[Fe^{2+}]$.
E) Cut Cu electrode in half.

'All Answers in the Scantron Sheets

47) What is the value for K_c if [CO] = 0.025, [H_2] = 0.013 and [CH_3OH] = 0.0028 at equilibrium for the following reaction:

$$CH_3OH(g) \rightleftharpoons CO(g) + 2\,H_2(g)\ ?$$

A) 1.5×10^{-3}
B) 8.6
C) 9.1×10^{-7}
D) 6.6×10^{2}
E) 0.12

48) Which of the following would NOT be considered a buffer solution?

A) 0.1 M NH_3/0.1 M NH_4Cl
B) 0.1 M HNO_3/0.1 M $NaNO_3$
C) 0.1 M $HC_2H_3O_2$/0.1 M $NaC_2H_3O_2$
D) 0.1 M H_2SO_3/0.1 M $NaHSO_3$
E) 0.1 M H_3PO_4/0.1 M NaH_2PO_4

49) Lead, water, sulfur, and arsenic have specific heats of 0.128, 4.18, 0.706, and 0.329 J g^{-1} $^{o}C^{-1}$, respectively. Which of the following would need the smallest quantity of heat to change the temperature of 5 g by 10°C?

A) They all absorb the same amount of heat to change the temperature by 10°C
B) lead
C) water
D) arsenic
E) sulfur

50) Gases emitted during volcanic activity often contain high concentrations of hydrogen sulfide and sulfur dioxide. These gases may react to produce deposits of sulfur according to the equation:

$$2\,H_2S(g) + SO_2(g) \rightarrow 3\,S(s) + 2\,H_2O(g)$$

For the complete reaction of 6.41 mol of hydrogen sulfide:

A) 308 g of sulfur is formed
B) 628 g of total reactants are consumed
C) 231 g of water vapor is produced
D) 410 g of sulfur dioxide is consumed
E) 320 g of total products result