

**Faraday's constant is 96,500 c/mole of electrons.**

A.(16) An electrochemical cell is prepared with a strip of manganese metal dipping in to a 1.0 M  $\text{MnSO}_4$  solution is connected by an external wire and a salt bridge to a silver wire dipping into a 1.0 M  $\text{AgNO}_3$  solution.

1. Write the half reaction occurring at the anode in a spontaneous reaction? \_\_\_\_\_
2. Write the balanced overall spontaneous reaction. \_\_\_\_\_
3. What is the  $\Delta E$  for the cell? \_\_\_\_\_
4. Is the cell voltage given in question 3 above the standard cell voltage? yes no  
If not explain why it is not.
5. Which direction are the anions flowing in the salt bridge?  
silver to manganese      manganese to silver      both directions
6. If the  $\text{MnSO}_4$  solution was 0.1 M and the  $\text{AgNO}_3$  solution was 1.5 M, the cell voltage be  
higher than standard.      lower than standard.      unchanged from standard.
7. If a steady current of 1.5 amps flowed for 20 minutes in the cell, how many grams of silver would be deposited on the silver wire? \_\_\_\_\_g

B.(4) If 1.56 g of a metal, M, is deposited from a  $\text{M}^{2+}$  solution in 20 minutes with a current of 1.29 amps, what is the molar mass of the metal?

C.(10) 1. A metal that will reduce  $\text{Br}_2$  to  $\text{Br}^-$  but not  $\text{I}_2$  to  $\text{I}^-$ .      Fe      Cu      Hg      Au

2. A metal that will not be dissolved (oxidized) by **neither**  $\text{HCl}$  or  $\text{HNO}_3$ .      Zn      Au      Pb

3. The equilibrium constant and  $\Delta G^\circ$  for the reaction,  $2\text{Al}^{3+} + 3\text{H}_2 \rightleftharpoons 2\text{Al} + 6\text{H}^+$  are \_\_\_\_\_ and \_\_\_\_\_ respectively.

very small, negative      about 1, zero      very large, negative  
very small, positive      very large, positive

4. What is reacting at the cathode during the **recharging** of a lead-acid battery and what is the product of the reaction?       $\text{Pb}^{2+}$ ,  $\text{PbO}_2$        $\text{PbSO}_4$ ,  $\text{PbO}_2$        $\text{PbSO}_4$ ,  $\text{Pb}$        $\text{Pb}^{2+}$ ,  $\text{Pb}$

5. Could sodium be used as a sacrificial anode to protect the hull of a ship against corrosion? Explain.

D.(10) Consider the experiment for the reaction,  $A + 2B \rightleftharpoons 3C$ .

Experiment	Initial [A]	Initial [B]	Rate( $\Delta[C]/s$ )
1.	0.0080	0.015	$3.0 \times 10^{-4}$
2.	0.0100	0.015	$3.0 \times 10^{-4}$
3.	0.0040	0.030	$1.2 \times 10^{-3}$

1, 2. What is the order of reaction with respect to A? \_\_\_\_\_ with respect to B? \_\_\_\_\_

3. What is the overall order of the reaction? \_\_\_\_\_

4. What is the  $-\Delta[A]/s$  in experiment 1? \_\_\_\_\_

5. What is the value for the specific rate constant (with units) as calculated from experiment 3?  
\_\_\_\_\_

E. (10) 1 A mixture of  $H_2(g)$  and  $O_2(g)$  can be kept a long time at room temperature for a long time without any change but when a lit match is brought into the presence of a mixture of  $H_2(g)$  and  $O_2(g)$ , the reaction occurs immediately and continues until completion of the reaction. Which is the best explanation for this?

- The lit match acts like a catalyst.
- The increase in T lowers the activation energy.
- The increase in T increases the kinetic energy of the molecules so that some will collide hard enough to react and reach the activated state.
- The smoke from the match provides the small suspended solid nuclei on which the reaction can occur.

2. Addition of a catalyst in a chemical reaction

- increases the fraction of reactant molecules with a given kinetic energy.
- provides an alternate pathway with a different activation energy.
- changes the  $\Delta G$  of the reaction.
- decreases the enthalpy change of the reaction.

3. The physical basis of the atmospheric greenhouse effect is that gases known as greenhouse gases

- transmit infrared light from the sun but absorb visible radiation reradiated from the earth.
- transmit visible light from the sun but absorb infrared radiation reradiated from the earth.
- absorb visible and ultraviolet light from the sun and reemit it as infrared radiation.
- prevent convective loss of heat from the surface of the earth.

4. Which of the following is not true concerning acid rain?

- Acid rain can result from the reactions of  $NO_2$  and  $SO_2$  with water vapor in the atmosphere.
- There are significant natural sources of acid rain.
- Acid rain can be decreased by lowering emissions of sulfur dioxide.
- Sulfur dioxide can be removed from exhaust gas sources by a reaction with limestone ( $CaCO_3$ ) to form calcium sulfate.

5. Chlorofluorocarbons

- are usually not reactive in the troposphere.
- are photodissociated in the stratosphere to form chlorine atoms.
- have a very long resident effect in the stratosphere.

Which statement(s) is(are) true?

- a. A, B, C      b. A, C      c. B, C      d. C

F.(3) Draw a transition state diagram for an endothermic reaction.

G.(4) If 8.0 g of substance A is allowed to react according to the equation,  $A \rightleftharpoons 2B$ , via a first order reaction and only 1.0 gram is left after 3.0 minutes, what is the half-life for the reaction and what is the specific rate constant?  $\ln([A]_0/[A]) = kt$

$$t_{1/2} = \text{_____} \quad k = \text{_____}$$

H.(3) Propose a rate determining elementary step for the reaction,  $2A + B \rightleftharpoons C$  if the rate law expression is  $\text{rate} = k[A]^2[B]^0$ .

I, J. (40) Circle the best response. **OMIT any three questions total in parts I and J (rest of the exam)**  
**Clearly mark those you omit.**

1. Solids without long-range microscopic order in their structures are called  
a. amorphous.    b. crystalline.    c. salts.    d. metals.
2. X-ray diffraction patterns of a crystal can be used to determine  
A. the perpendicular distance between parallel planes in the crystal.  
B. its rotational symmetry and thus the type of crystal system.  
C. interatomic distances within the crystal.

Which statement(s) is(are) true?

- a. A, B, C      b. A, C      c. B, C      d. C      e. A, B

3. The unit cells illustrating the seven crystal systems differ from each other in  
a. the lengths of the three edges.  
b. the angles between the three edges.  
c. the lengths of the three edges **and** the angles between the three edges.
4. For a face-centered cubic lattice, each **corner** contributes \_\_\_\_\_ lattice point to the unit cell.  
a. 1/8      b. 1/4      c. 1/2      d. 1
5. The forces holding the molecules together in a molecular solid are  
a. ionic bonds      b. covalent bonds      c. van der Waals forces      d. hydrogen bonds
6. A certain solid is a good insulator, is brittle and has a high melting point. The substance readily conducts electricity when molten. This substance is most likely \_\_\_\_\_ in nature.  
a. molecular      b. covalent      c. ionic      d. metallic
7. In diamond, each carbon atom is covalently bonded to \_\_\_\_\_ other carbon atoms.  
a. 2    b. 4    c. 6    d. 8    e. 12

8. In metals existing in either cubic or hexagonal close packing, each atom has \_\_\_\_\_ nearest neighbors. a. 2 b. 4 c. 6 d. 8 e. 12

9. Which statement regarding defects in crystals is true?

- a. Defects are rather common and are often vacancies or displacements of atoms or ions.
- b. Defects in pure crystalline substances are rare.
- c. Crystalline defects in metals do not significantly affect their electrical conductance.
- d. Irradiation of crystals with subatomic particles or high energy radiation is **not** known to cause defects in crystals.

10. Which statement is **NOT** true regarding liquid crystals.

- a. The molecules retain some sort of orientational order even though the lattice structure is broken down.
- b. The orientation of molecules in a liquid crystal is sensitive to small magnetic fields but not electrical fields.
- c. Molecules that are long and rod-like are more likely to behave like liquid crystals.

11. Materials science involves the fabrication of tailored materials with required properties. These materials often involve A. ceramics (silicon). B. polymers (carbon). C. metals.

Which statement(s) is(are) true?

- a. A, B
- b. A, C
- c. B, C
- d. A, B, C

12. The energy of the band gap between the conductance and valence bands is increasing in which sequence? a. diamond, silicon, metal b. metal, silicon, diamond c. diamond, metal, silicon

13. If silicon is doped with antimony,

- a. a positive hole is created.
- b. less energy is required to promote electrons from the valence band to the conduction band.
- c. the electrical conductivity of the silicon is decreased.
- d. all of the above are true.

14. Which is not a silicate ceramic?

- a. alumina
- b. glass
- c. cement
- d. pottery

15. Which statement(s) characterize(s) ceramics.

- A. Ceramics tend to be hard and resistant to wear.
- B. Ceramics tend to be good electrical insulators.
- C. Ceramics tend to retain their strength at high temperatures.
- D. Ceramics tend to be brittle.

- a. A, B,
- b. A, B, C,
- c. B, D
- d. B, C
- e. A, B, C, D

J. Mark those of the following which are true statements.

\_\_\_1. Visible light does not have enough energy to promote electrons from the valence band to the conduction band in semiconductors.

\_\_\_2. Semiconductors are often used in amplifying current and converting alternating current to direct current.

\_\_\_3. Building materials such as bricks, concrete, glass and polyvinyl chloride all involve silicates.

\_\_\_4. Quartz is an infinite network solid composed of  $\text{SiO}_2$ .

- \_\_\_5. Firing a ceramic causes sintering, in which the fine particles of the ceramic start to merge together by diffusion at high temperatures.
- \_\_\_6. The thermal expansion of soda-lime glass is higher than borosilicate glass (pyrex).
- \_\_\_7. Cement, concrete and mortar are synonymous terms.
- \_\_\_8. Silicon Carbide (SiC, Carborundum) is much like diamond and is used as an abrasive.