There are four parts (A-D) in this paper, please answer these questions in order.

A :

1. (2% for each answer, 8% total for the question)

For the rate constant of a first order elementary reaction, $A \rightarrow P$, the frequency factor is 10^8 s^{-1} and the activation energy 42 kJ mol^{-1}. Answer the following questions using a proper unit.

    (a)　The rate constant at 25℃ ?

    (b)　If $[A]_0 = 0.10M$, what is the initial reaction rate at 25℃ ?

    (c)　What is the instantaneous reaction rate at 25℃ after 5.0 sec of reaction time?

    (d)　What is the half-life for the reaction?

2. (3% for each answer, 9% total for the question)

    (a)　What is constant volume heat capacity, C_v, in J K^{-1} for 1.0 mol of Helium gas?

    (b)　The gas absorbs 100 J of heat and at the same time, performs 27 J of expansion work. What is the change in the internal energy of the gas, ΔU, in this process?

    (c)　What is the temperature change, ΔT, of the gas?

3. (4% for each answer, 8% total for the question)

Calculate the energy levels of the π-network in butadiene, C_4H_6, using **the particle in the box** model.

To calculate the box length, assume that the molecule is linear and use the values 135 and 154 pm for C=C and C–C bonds (1 pm = 10^{-12} m).

    (a)　What is the box length in the model using the above given bond lengths?

    (b)　What is the wavelength of light required to induce a transition from the ground state to the first excited state?

Useful constants

Ideal gas constant, R = 8.314 J K^{-1} mol^{-1}

Plank constant, h = 6.626 x 10^{-34} J s

Mass of an electron, m = 9.11 x 10^{-31} kg

Speed of light, c = 2.998 x 10^8 m s^{-1}

B：

4. Draw simple band pictures for the following materials (5 %); Suggest possible dopants for the n-type and p-type semi-conductors. (2%).

   (1) insulator
   (2) conductor
   (3) pure semi-conductor
   (4) p-type semi-conductor
   (5) n-type semi-conductor

5. Using Molecular Orbital Theory, calculate the bond order of the following molecules. Which will have the shortest and longest bonds. (8%).
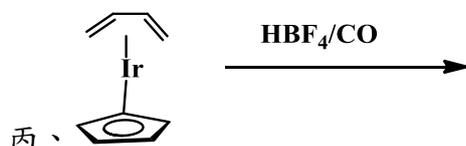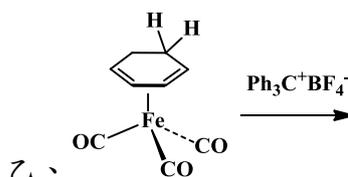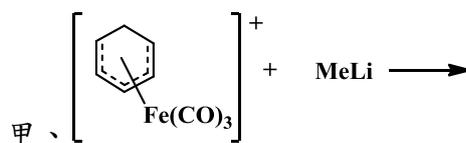
   甲、NO^+
   乙、NO
   丙、NO^-

6. Compare the CsCl and NaCl lattices, particularly their coordination numbers. (4 %).

7. Predict the products of the following reactions. (6 %).

C:

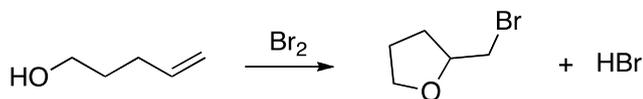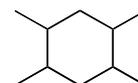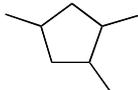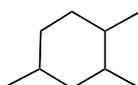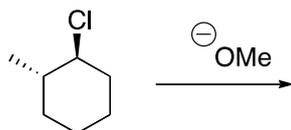8. For the following transformation below, provide a detailed step-wise mechanism showing the electron flow using the curved arrow formalism.　(4%)
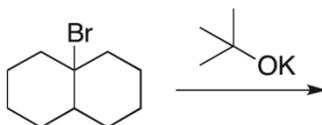

9. Which pair of the following compounds are constitutional isomers?　(2%)

A.　　　　　　　　　　B.　　　　　　　　　　C.　　　　　　　　　　D.

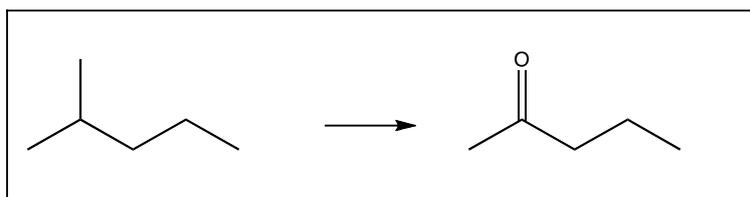10. What is the product of the following elimination?　(2%)

11. Draw the mechanism and product for the following elimination.　(6%)

12. Predict the major product(s) of the following reaction.　(4%)

13. Propose an efficient sequence of reactions to accomplish the following transformation.　(5%)

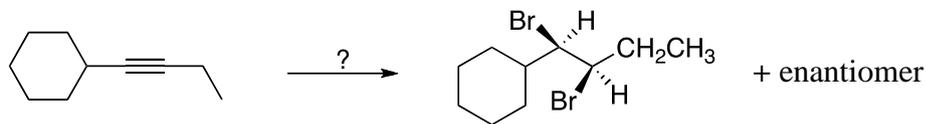14. Which sequence of reactions is expected to produce the product below as the final, and major, organic product?　(2%)

(A)　1)Br_2;　　　　　　　　2) H_2, Lindlar's cat.;

(B)　1)H_2, Lindlar's cat.;　　2) Br_2;

(C)　1)Br_2;　　　　　　　　2) Na, NH_3(l) ;

(D)　1)Na, NH_3(l);　　　　　2) Br_2 ;

(E)　1)Br_2;　　　　　　　　2) H_2, Pt

D:

15. A 0.8 g sample of primary standard Na_2CO_3 required 50.9 mL of an H_2SO_4 solution to reach the end point of the reaction. What is the molar concentration of H_2SO_4?　(10%)

$CO_3^{2-} + 2H^+ \rightarrow H_2O + CO_{2(g)}$
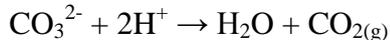
(Na = 23.0, C = 12.0, O = 16.0)

16. The Zn in a 1.0 g sample of foot powder was titrated with 60.0 mL of 0.05 M EDTA. Calculate the percent Zn in this sample. (Zn = 65.4)　(10%)

17. How would you prepare 0.5 L of the following solution:0.03 M $CuSO_4 \cdot 5H_2O$ from the solid? (5%)

(Cu = 63.5, S = 32.1, O = 16.0, H = 1.0)