B 卷：普通化學(30 題[1-30]，每題 1 分)、材料熱力學(20 題[31-50]，每題 1.5 分)、有機化學(30 題 [51-80]，每題 1 分)。滿分 90 分。倒扣至零分為止。

※本卷全部皆為選擇題，請以 2B 鉛筆劃卡作答。

科目名稱： 普通化學

每題為 4 選 1，每一題答對得 1 分，答錯倒扣 0.25 分。

1. Which of the followings statement is correct in regarding to the referred reaction?
   Ⓐ CaO is acid in this reaction $CaO + H_2O \rightarrow Ca^{2+} + 2\ OH^-$
   Ⓑ H_2O is acid in this reaction $CaO + H_2O \rightarrow Ca^{2+} + 2\ OH^-$
   Ⓒ HCO_3^- is base in the reaction $HCO_3^- + NH_3 \rightarrow NH^{4+} + CO_3^{2-}$
   Ⓓ none of the above

2. Which of the following contains the smallest number of water molecules?
   Ⓐ 1.0 g of liquid water at $0^{\circ}C$　　　　Ⓑ 1.0 g of solid water at $0^{\circ}C$
   Ⓒ 1.0 ml of solid water at $0^{\circ}C$　　　　Ⓓ 1.0 ml of liquid water at $0^{\circ}C$.

3. The boiling temperature of pure water is $100^{\circ}C$ at 1 atm.　The boiling point of the water solution of alcohol should be,
   Ⓐ $>100^{\circ}C$　　　　Ⓑ $=100^{\circ}C$　　　　Ⓒ $<100^{\circ}C$　　　　Ⓓ no basis for judgement

4. What will happen when milk is poured over sour fruit?
   Ⓐ make the fruit disslove　　Ⓑ becoming clear　　Ⓒ become solid　　Ⓓ become curdle

5. Which of the following water solutions has the smallest pH value?
   Ⓐ 0.01N NaOH　　　　Ⓑ 0.002N HNO_3　　　　Ⓒ 0.01N HCl　　　　Ⓓ 0.01N C_2H_5OH

6. 1 g of $Zn(OH)_2$ in 1 liter of water is not soluble.　How would you do to dissolve the $Zn(OH)_2$?
   Ⓐ add another 1 liter of water　　　　Ⓑ cook the solution
   Ⓒ add 1N of NaOH solution　　　　　Ⓓ add 1 N of HNO_3 solution

7. The splitting of a 12C atom into two 6Li atoms will be,
   Ⓐ endothermic　　　　Ⓑ exothermic　　　　Ⓒ no heat involved　　　　Ⓓ not possible

8. Which of the following compounds is water insoluble?

  Ⓐ KCl　　　　　　　Ⓑ LiCl　　　　　　　Ⓒ $Sr(NO_3)_2$　　　　　Ⓓ $BaSO_4$

9. Which of the following is the most active reducing agent?

  Ⓐ Cs^+　　　　　　Ⓑ F_2　　　　　　　Ⓒ Br^-　　　　　　Ⓓ Na^+

10. Which of the following is a correct statement?

  Ⓐ HCl is more ionic than HF　　　　　Ⓑ $BeCl_2$ is more ionic than $BaCl_2$

  Ⓒ $AlCl_3$ is more ionic than CsCl　　　　Ⓓ none of the above

11. Please make the following conversion: x °C to Kelvin temperatures.

  Ⓐ (x + 273) K　　Ⓑ (x - 32) K　　Ⓒ (x + 100) K　　Ⓓ (x + 32) K.

12. A phase diagram exhibits the various phases (gas, liquid, and solid) of a substance at different pressure and temperature. Take H_2O for an example, the diagram contains three important curves, each of which represents the conditions of temperature and pressure at which the various phases can coexist at equilibrium. Please identify how many phases within the critical point are at equilibrium on the three curves except the triple point.

  Ⓐ 1　　　　　　　Ⓑ 3　　　　　　　Ⓒ 4　　　　　　　Ⓓ 2.

13. What is molarity of Na^+ in a solution of NaCl (AW of Na: 23g, AW of Cl: 35g) whose salinity (grams of NaCl in 1kg of seawater) is 5.8 if the solution has a density of 1g/ml? Molarity (M) is defined as the number of moles of solute in a liter of solution (mole/liter).

  Ⓐ 0.25M　　　　　Ⓑ 0.01M　　　　　Ⓒ 1M　　　　　　　Ⓓ 0.1M.

14. The element silver consists in nature of two isotopes, ^{107}Ag with atomic mass 106.905 amu, and ^{109}Ag with atomic mass 108.905 amu. Assume the accepted atomic weight of Ag is 107.905. Please calculate the relative amounts of ^{107}Ag and ^{109}Ag in this case.

  Ⓐ 49%, 51%　　　Ⓑ 60%, 40%　　　Ⓒ 30%, 70%　　　Ⓓ 50%, 50%

15. Calculate the pH of a solution produced by mixing 0.4 L of 0.1 M NH_4Cl with 0.2 L of 0.1 M NaOH. Hint: $NH_4^+{}_{(aq)} \rightleftharpoons NH_{3(aq)} + H^+{}_{(aq)}$, $k_a = 5 \times 10^{-10}$;

    $NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_{4(aq)}^+ + OH^-{}_{(aq)}$, $k_b = 2 \times 10^{-5}$.

  Ⓐ 5.5　　　　　　　Ⓑ 7　　　　　　　　Ⓒ 9.3　　　　　　　Ⓓ 12.

16. The chemistry of hydrocarbon derivatives is often dominated by the nature of their functional groups. Please name the following popular functional groups: R-COH, R-OH, and R-COOR'. Please note R and R' represent organic groups.

    Ⓐ Aldehyde, Alcohol, and Ester　　　　　　Ⓑ Aldehyde, Alkene, and Ether

    Ⓒ Ketone, Alcohol, and Carboxylic acid　　　Ⓓ Ester, Alcohol, and Aldehyde.

17. Please identify the equilibrium-constant expression for the following reaction, and whether the reaction is homogeneous or heterogeneous.

$NH_4NO_{2(s)} \rightleftharpoons N_{2(g)} + 2H_2O_{(g)}$
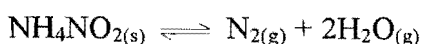
    Ⓐ $K = [N_2][H_2O]^2 / [NH_4NO_2]$, homogeneous　　Ⓑ $K = [N_2][H_2O]^2 / [NH_4NO_2]$, heterogeneous

    Ⓒ $K = [N_2][H_2O]^2$, homogeneous　　　　　　Ⓓ $K = [N_2][H_2O]^2$, heterogeneous.

18. The yellow light given off by a sodium lamp has a wavelength of 600 nm. What is the corresponding frequency? Hint: the speed of light: 3×10^8 m/s.

    Ⓐ 5×10^{14} Hz　　　　Ⓑ 10^{15} Hz　　　　Ⓒ 5×10^{13} Hz　　　　Ⓓ 10^{16} Hz.

19. Copper (Cu), silicon (Si), and diamond (C) are typical metal, semiconductor, and insulator, respectively. From the molecular orbital model, they can be readily distinguished by their energy gaps. Please identify their energy gaps in an decreasing order.

    Ⓐ C > Si > Cu　　　　Ⓑ Cu > Si > C　　　Ⓒ Si > C > Cu　　　　Ⓓ C > Cu > Si.

20. Allotropes are different forms of the same element in the same state. Please identify which is not the allotrope of carbon (C).

    Ⓐ diamond　　　　Ⓑ carbon nanotube　　　Ⓒ graphite　　　　Ⓓ carbon oxide.

21. Consider a binary system (components A and B) with two phases (α and β) in equilibrium. Which one of the followings is true:

    Ⓐ $a_A^\alpha = a_B^\alpha$,　　　Ⓑ $a_A^\alpha = a_A^\beta$,　　　Ⓒ $a_A^\alpha \neq a_A^\beta$,　　　Ⓓ $a_B^\alpha \neq a_B^\beta$.

22. In two-component system, the maximum number of phases can co-exist at a fixed pressure is

    Ⓐ 0　　　　　　　Ⓑ 1　　　　　　　Ⓒ 2　　　　　　　Ⓓ 3

23. In the electroplating of Cu in $CuSO_4$ solution, how many moles of Cu is reduced when 1.93×10^5 coulombs of electric charges are passed through the electrolytic cell?

    Ⓐ 0.5　　　　　　Ⓑ 1.0　　　　　　Ⓒ 2.0　　　　　　Ⓓ 4.0.

24. Which of the following reaction could do work of expansion on its surroundings?

　Ⓐ$CH_4(g) + 2 O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$,　　　Ⓑ$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$,

　Ⓒ(C) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$,　　　　　Ⓓ$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$.

25. The mass of a proton is

　Ⓐ 1.67×10^{-27} kg,　　Ⓑ 9.11×10^{-27} kg,　　Ⓒ 1.00×10^{-24} g,　　Ⓓ 1 g.

26. A sodium atom has 11 electrons. How many protons does it contain?

　Ⓐ 11,　　　　　Ⓑ 12,　　　　　Ⓒ 23,　　　　　Ⓓ 24.

27. The formula of potassium hydrogen sulfite is given as

　Ⓐ KHS_2,　　　Ⓑ $KHSO_3$,　　　Ⓒ $KHSO_4$,　　　Ⓓ KHS_2O_3.

28. What mass of hydrogen can be produced in HCl solution if 15 A of current is passed for 1.0 h?

　Ⓐ 36.5 g　　　Ⓑ 18.3 g　　　Ⓒ 0.56 g　　　Ⓓ 0.28g.

29. The enthalpy change of a specific reaction is -890 kJ. This reaction is a process of

　Ⓐ endothermic　　Ⓑ exothermic　　Ⓒ at equilibrium,　　Ⓓ none of the above.

30. Estimate the pH of 2.0 M solution of H_2SO_4.

　Ⓐ 2.0　　　　　Ⓑ 1.0　　　　　Ⓒ -2　　　　　Ⓓ -0.30.

科目名稱： 材料熱力學
每題為 4 選 1，每一題答對得 1.5 分，答錯倒扣 0.375 分。

31. Assume $P_A^O = 0.06$atm and $P_B^O = 0.07$ atm, when an ideal solution of 40% of A and 60% of B, the partial pressures of A and B are:

　Ⓐ 0.024atm and 0.042atm　　　　Ⓑ 0.02 atm and 0.024 atm

　Ⓒ 0.024atm and 0.02atm　　　　　Ⓓ 0.036 atm and 0.054atm

32. When a negative-deviated solution consists 90% of A and 10% of B, assuming $P_A^O = 0.04$atm and $P_B^O = 0.05$ atm, which of the following partial pressure of A and B may be true:

　Ⓐ 0.036atm and 0.005atm　　　　Ⓑ 0.072atm and 0.01atm

　Ⓒ 0.018atm and 0.0025atm　　　　Ⓓ 0.1atm and 0.0125atm

33. When an binary ideal solution with $X_A = 0.6$ $X_B = 0.4$, assuming $P_A^O = 0.04$atm and $P_B^O = 0.06$ atm, which of the following is total vapor pressure ($P_A + P_B$):

 Ⓐ 0.05atm,   Ⓑ 0.051atm,   Ⓒ 0.052atm,   Ⓓ 0.048atm,

34. When A and B form Henrian solution behavior with very strong negative deviation, which one of the following statement is correct:

 Ⓐ there is strong attraction force between A and B

 Ⓑ there is no interaction between A and B

 Ⓒ the partial pressure of each component is much higher than the Raoultian solution

 Ⓓ none of above is correct

35. In the Ellingham diagram, two reactions $A + O_2 = AO_2$(steeper slope), $B + O_2 = BO_2$, intersects at temperature of 500℃, **when** A, AO_2, B, BO_2 all placed in a closed chamber and changing the temperature from 500℃ **to 600℃**, what could happen?

 Ⓐ more B will be oxidized   Ⓑ more A will be oxidized

 Ⓒ more AO_2 will be reduced   Ⓓ no significant change

36. After adding oxide impurity into a mixture of metal A and metal oxide AO_2, in order to further oxidize metal A

 Ⓐ equilibrium pO_2 reduced   Ⓑ equilibrium pO_2 increased

 Ⓒ metal A will not be oxidized   Ⓓ no change in equilibrium pO_2

37. During the oxidation of metal A, as the temperature increases and passes A's melting point, the Ellingham lines should look like

 Ⓐ elbow upward Ⓑ elbow downward Ⓒ curve up Ⓓ no change

38. In most oxidation of metal, as the temperature decreases, the equilibrium oxygen partial pressure will

 Ⓐ increase Ⓑ remain the same Ⓒ depends on the structure of oxide Ⓓ decrease

39. Metal has higher stability in ambient environment because it

 Ⓐ has low equilibrium pO_2 Ⓑ tends to form oxide

 Ⓒ has high equilibrium pO_2 Ⓓ none of above

40. Compare the oxidation of metal A, as the temperature increases and passes the melting point of AO_2, the Ellingham lines should look like
    (A) entropy change reduced
    (B) elbow upward
    (C) curve up
    (D) extent of enthalpy change increased

41. In a real gas system, when the van der Waals equation, $PV^3-(Pb+RT)V^2+aV-ab=0$, is applicable, the pressure at the critical temperature will be
    (A) $a/(27b^2)$
    (B) $3b$
    (C) $8a/(27bR)$
    (D) a/V^2

42. Which of the following is not a state function?
    (A) entropy
    (B) heat
    (C) enthalpy
    (D) pressure

43. As an ideal gas undergoes a reversible isothermal process from V_1 to V_2, what is the work done by the system?
    (A) $RT\ln(V_2/V_1)$
    (B) $RT\ln(V_1/V_2)$
    (C) $RT\ln(P_2/P_1)$
    (D) $RT\ln(P_1/P_2)$

44. An ideal gas at 300K has a volume of 15 liters at a pressure of 15 atm. Calculate the work done by the system for a reversible adiabatic expansion to a pressure of 10 atm
    (A) 0
    (B) 5130J
    (C) 4260J
    (D) 2150J

45. An ideal gas at 300K has a volume of 15 liters at a pressure of 15 atm. Calculate the heat entering or leaving the system for a reversible adiabatic expansion to a pressure of 10 atm
    (A) 0
    (B) 5130J
    (C) 4260J
    (D) 2150J

46. An ideal gas at 300K has a volume of 15 liters at a pressure of 15 atm. Calculate the change in the internal energy for a reversible adiabatic expansion to a pressure of 10 atm
    (A) -5130J
    (B) -4260J
    (C) -2150J
    (D) 2150J

47. An ideal gas at 300K has a volume of 15 liters at a pressure of 15 atm. Calculate the change in the enthalpy when the gas undergoes for a reversible adiabatic expansion to a pressure of 10 atm
    (A) -2365J
    (B) -738J
    (C) -8549J
    (D) -1240J

48. The initial state of one mole of a monatomic ideal gas is P= 10 atm and T= 300K. Calculate the change in the entropy of the gas for a constant-volume decrease in the pressure to 5 atm
    (A) 2.75J/K
    (B) -2.75J/K
    (C) 8.65J/K
    (D) -8.65J/K

49. Calculate ΔS in expanding 1 mol of ideal gas at 25°C from 10 to 100 cm³

　Ⓐ5.31J/K　　　　　Ⓑ19.14J/K　　　　　Ⓒ37.24J/K　　　　　Ⓓ28.43J/K

50. The melting point of silver is 1234K and the heat of fusion is 11.2 kJ/mole. For the case of freezing of super-cooled liquid silver at 1073K, what is the entropy change of the sytem?
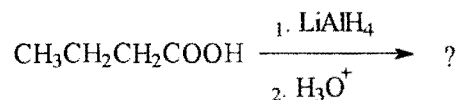
　Ⓐ-9.03J/K　　　　　Ⓑ-23.15J/K　　　　　Ⓒ1.31J/K　　　　　Ⓓ-1.31J/K

科目名稱: 有機化學

每題為 4 選 1,每一題答對得 1 分,答錯倒扣 0.25 分。

51. Polyester is made by what kind of monomers?
　Ⓐ a diacid and a diamine　　　　　　Ⓑ a diacid and a dialcohol
　Ⓒ a dianhydride and a diamine　　　　Ⓓ a dialcohol and a diamine

52. What is the product of the following reaction?

$$CH_3CH_2CH_2COOH \xrightarrow[\text{2. } H_3O^+]{\text{1. } LiAlH_4} ?$$

　Ⓐ $CH_3CH_2CH_2CHO$　Ⓑ $CH_3CH_2CH_2COOCH_3$　Ⓒ $CH_3CH_2CH_2CN$　Ⓓ $CH_3CH_2CH_2CH_2OH$
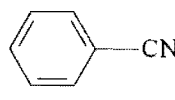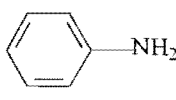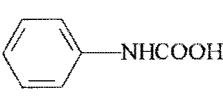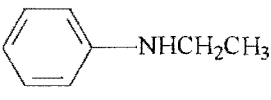
53. Which compound is more acidic?
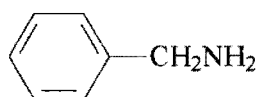
　Ⓐ CH_3CH_2COOH　Ⓑ $BrCH_2CH_2COOH$　Ⓒ $BrCH_2COOH$　Ⓓ CH_3CH_2OH

54. Which of the following polymers is a conductive polymer?
　Ⓐ polyaniline　　　Ⓑ polycarbonate　　　Ⓒ PVC　　　Ⓓ polystyrene

55.

Ⓐ (phenyl)—CN   Ⓑ (phenyl)—NH_2 Ⓒ (phenyl)—NHCOOH   Ⓓ (phenyl)—$NHCH_2CH_3$
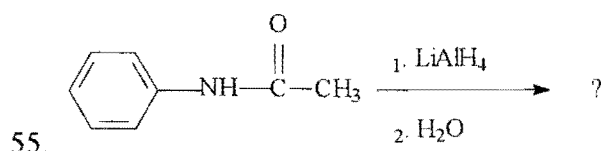
56. The name of the following compound is

Ⓐ toulene   Ⓑ aniline   Ⓒ benzylamine   Ⓓ pyridine

57. Which is a secondary amine ?

58. What is the IUPAC name of the following compound?
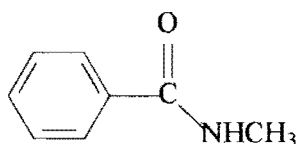
Ⓐ N-methylbenzamide   Ⓑ N-methylaminophenyl ketone

Ⓒ N-methylbenzoylamide   Ⓓ N-methylaminobenzoate

$$CH_3CH_2CCl \xrightarrow[2. \ H_3O^+]{1. \ LiAlH_4} ?$$

59.
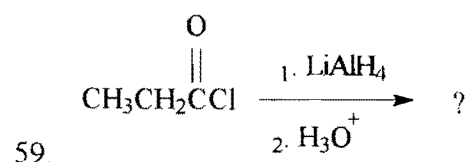
Ⓐ $CH_3CH_2CH_2COOH$ Ⓑ $CH_3CH_2CH_2OH$ Ⓒ $CH_3CH_2CH_2CH_3$ Ⓓ $CH_3CH_2CH_2CHO$

60. Which feature in the ^1H NMR spectrum provides information about the electronic environment of the protons in a compound?

   Ⓐ number of signals　　Ⓑ integration of signals　　Ⓒ splitting of signals　　Ⓓ chemical shift

61. A chemical name has three parts in the IUPAC system of nomenclature, which of the following description is not one of them?

   Ⓐ Prefix　　　　　　Ⓑ Suffix　　　　　　　Ⓒ Functional group　　　Ⓓ Parent name

62. Regarding to the bond polarity, which of the following descriptions is correct?

   Ⓐ When carbon bonds to a metal, the carbon bears a partial negative charge ($\delta+$).

   Ⓑ Electron-rich species are called nucleophiles.

   Ⓒ H_3O^+ is nucleophilic

   Ⓓ Electron-rich atom gets electron pair from electron-poor atom to form the bonding.

63. Regarding to the functional groups with carbon singly bonded to an electronegative atom,

   Ⓐ it includes a non-polar bond.

   Ⓑ the π electron can be delocalized.

   Ⓒ the electronegative atom bears a partial negative charge.

   Ⓓ it can be found in the Ketone.

64. Resonance is a very useful concept for

   Ⓐ explaining the stability of molecules based on the delocalization of electron.

   Ⓑ explaining the possible isomer forms.

   Ⓒ explaining the change of molecular conformation.

   Ⓓ explaining the enhanced stability of molecules based on the number of π electrons.

65. The transition state involved in a chemical reaction

   Ⓐ can be directly observed

   Ⓑ has a lower energy state than that of reactant

   Ⓒ frequently determines the activation energy

   Ⓓ is related to a chemical structure with minimum energy.

66. For the double bond in an alkene,

   Ⓐ the π bond must be broken for the rotation around it.

   Ⓑ the p orbitals are perpendicular to each other

   Ⓒ breaking π bond can cause the p orbitals to be parallel

   Ⓓ the electrons in σ bond are delocalized.

67. Which of the following compounds has a functional group with carbon-oxygen double bond?
    (A) Ethanol　　　　(B) Carboxylic acid　　　　(C) Isoprene　　　　(D) Cyclohexene.

68. For the alkanes,
    (A) the length of average C-C bond is about 124 ± 1 pm.
    (B) the bond strength of C-C bond is of 255 ± 20 kJ/mol.
    (C) the strength of a typical C-H is around 500 ± 20 kJ/mol.
    (D) the length of C-H bound is of 109 ± 1 pm.

69. For the conformations of ethane,
    (A) the staggered conformation is more stable.
    (B) the eclipsed conformation is more stable.
    (C) all different conformations are equally stable.
    (D) the rotation barrier is considerable, which limits the possible extent of rotation around the single bound.

70. Which of the following compounds has the cis-trans stereoisomers
    (A)2-Methylpropene　　　(B)Isoprene　　　(C)1,2-Dimethylcyclopropane　　　(D)2-Methylbuta-1,3-diene.

71. Polyphenols in green tea and other nature products are often considered as excellent antioxidants. The chemistry is similar to the oxidation of hydroquinone, which converts the hydroquinone to:
    (A) quinone　　　　(B) polyquinone　　　　(C) quinone aldhyde　　　　(D) benzoquinone

72. Epoxides represent the cyclic ethers with 3-membered rings.　　Which of the following descriptions is <u>INCORRECT</u>?
    (A) the 3-membered ring contains the atoms of two carbons and one oxygen.
    (B) the strain of the 3-membered ring give epoxides unique chemical reactivity.
    (C) epoxides undergo only the base-catalyzed reaction, but not the acid-catalyzed reaction.
    (D) epoxides react with Grignard reagents

73. Which of the following nomenclatures is <u>INCORRECT</u>?
    (A) R-SH → thiol　　　　　　　　　　(B) R-S-R → sulfate
    (C) $S_2O_8^{2-}$ → persulfate　　　　　　(D) SO_4^{2-} → sulfonic acid

74. Which description below about alcohols is <u>INCORRECT</u>?
　　Ⓐ A primary alcohol undergoes the oxidation reaction and form aldehydes.
　　Ⓑ A secondary alcohol undergoes the oxidation reaction and form carboxylic acids.
　　Ⓒ Dehydration of alcohols forms ethers.
　　Ⓓ Dehydration of a tertiary alcohol form alkene.

75. A mercapto group represents the capturer of mercury.　What is the reaction of this mercapto group?
　　Ⓐ $R-NH_2 + Mg$　　　　Ⓑ $R-NH_2 + Hg$　　　　Ⓒ $R-SH + Mg$　　　　Ⓓ $R-SH + Hg$

76. Which following description about carbonyl groups is <u>INCORRECT</u>:
　　Ⓐ a carbonyl group contains C=O bonding.
　　Ⓑ a carbonyl carbon atom is sp^2-hybridized.
　　Ⓒ a carbonyl compound is not planar due to the nonbonding electrons on oxygen.
　　Ⓓ a carbonyl group is polarized due to the high electro-negativity of oxygen.

77. Which of the following organic solvents is INCORRECT:
　　Ⓐ THF = tetrahydrofuran　　　　　　Ⓑ IPA = isopropyl alcohol
　　Ⓒ Acetone = propanal　　　　　　　　Ⓓ DMF = N, N-dimethylformamide

78. $R-NH_2$ adds to $>C=O$ to form:

　　Ⓐ an amide, $>C-NR$ with H　　Ⓑ an imine, $>C-NR$ with H

　　Ⓒ an amide, $>C=NR$　　Ⓓ an imine, $>C=NR$

79. How do you prepare Grignard reagents?
　　Ⓐ alcohols react with Magnesium in ether solvent
　　Ⓑ alcohols react with Germanium in ether solvent
　　Ⓒ alkyl halides react with Magnesium in ether solvent
　　Ⓓ alkyl halides react with Germanium in ether solvent

80. An acetyl group is: