

(即單選題)

一、單選題(答案請填於答案卡，每題 2.5 分，答錯倒扣 4/5 分，倒扣至本大題 0 分為止，共 100 分)

This is a 4-choice multiple choice test with 40 questions, and there is only one correct answer for each question. Students receive full credit for correct answers (2.5 pts/each), no credit for questions they do not attempt (0 pts/each), and a penalty for questions they answered incorrectly (- 4/5 pts/each). The total score is 100 points.

1. Which pair of the molecule and point group is correct?

- (A) CH_2Cl_2 , T_d (B) CHCl_3 , C_{3v} (C) CCl_4 , D_{4d} (D) CCl_2Br_2 , C_{2h}

2. An O_h XY_6 molecule exhibits two T_{1u} IR active modes. Which statement is true?

- (A) Each T_{1u} mode is triply degenerate, and each gives rise to one absorption in the IR spectrum of XY_6
(B) Each T_{1u} mode is triply degenerate, and each gives rise to three absorptions in the IR spectrum of XY_6
(C) Each T_{1u} mode is non-degenerate, and gives rise to one absorption in the IR spectrum of XY_6
(D) One of the T_{1u} modes is the symmetric stretching mode of XY_6

3. Elemental analytical data for a new, monomeric compound X is a requirement of publishing details of the compound in the literature, even when crystallographic and spectroscopic data are available. This is because:

- (A) elemental analysis is a requirement purely for historical reasons
(B) elemental analysis is the only method of confirming that the compound contains no solvate
(C) elemental analysis confirms the composition of the bulk sample
(D) elemental analysis confirms that the compound is a monomer and not a dimer or higher oligomer

4. You are trying to find out if a thiocyanate ligand, $[\text{NCS}]^-$, is bonded to a metal ion through the N or S atom. Which technique would be **MOST** useful to you?

- (A) ^{13}C NMR spectroscopy (B) mass spectrometry (C) UV-VIS spectroscopy (D) IR spectroscopy

5. Which statement is true about orbitals with t_{2g} symmetry?

- (A) MOs with t_{2g} symmetry are found for molecules belonging to the T_d point group
(B) Each MO in a t_{2g} set of orbitals is centrosymmetric
(C) A set of t_{2g} MOs consists of two degenerate orbitals
(D) MOs with t_{2g} symmetry are found for molecules belonging to the C_{2v} point group

注意:背面有試題

6. Which of the following does **not** contain a C_3 axis?

- (A) POCl_3 (B) $[\text{NH}_4]^+$ (C) $[\text{H}_3\text{O}]^+$ (D) ClF_3

7. In order to describe the bonding in some compounds, it is necessary to invoke 3-centre 2-electron interactions. In which one of the following are such interactions usually invoked?

- (A) $(\text{BeH}_2)_n$ (B) Al_2Cl_6 (C) $(\text{BeCl}_2)_n$ (D) Si_2H

8. A unit cell of ReO_3 consists of a cubic arrangement of Re atoms with O atoms centered along each edge of the cube. The coordination number of each Re atom is:

- (A) 6 (B) 3 (C) 8 (D) 2

9. Which statement is **incorrect**?

- (A) CaO crystallizes with the CsCl structure
(B) Wurtzite and zinc blende are polymorphs of ZnS
(C) β -Cristobalite is one crystalline form of SiO_2
(D) CaTiO_3 (perovskite) is an example of a double oxide

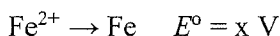
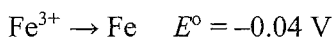
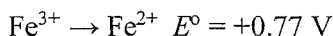
10. Within the principle of hard and soft acids and bases (HSAB), which pair of metal ion and donor atom is **BEST** matched?

- (A) Al^{3+} and O (B) Ag^+ and O (C) Li^+ and S (D) Ca^{2+} and S

11. When $[\text{EDTA}]^{4-}$ coordinates to a metal ion, M^{2+} , to give $[\text{M}(\text{EDTA})]^{2-}$, the number of chelate rings formed is:

- (A) 4 (B) 5 (C) 6 (D) 3

12. A potential (Latimer) diagram shows the following data:



What is the value of x ?

- (A) -0.44 (B) -0.81 (C) -0.40 (D) +0.73

13. The pK_a of HNO_2 is 3.37. The pH of a 0.01 mol dm^{-3} aqueous solution of HNO_2 is:
(A) 5.37 (B) 2.69 (C) 1.69 (D) 0.69
14. In neutral aqueous solution, E° for the $\text{Mn}^{3+}/\text{Mn}^{2+}$ couple is +1.54 V. At pH 14, E° for the $\text{Mn}(\text{OH})_3/\text{Mn}(\text{OH})_2$ couple is +0.15 V. Which of the following statements is **incorrect**?
(A) At pH 14, Mn(II) and Mn(III) both precipitate from aqueous solution as hydroxides
(B) Mn(III) is less stable with respect to reduction to Mn(II) at pH 14 than at pH 7
(C) The $\text{Mn}(\text{OH})_3/\text{Mn}(\text{OH})_2$ couple refers to an equilibrium involving Mn(III) and Mn(II)
(D) At pH 7, $\text{Mn}^{3+}(\text{aq})$ is a relatively strong oxidizing agent
15. A superacid is a stronger acid than?
(A) anhydrous HCl (B) anhydrous HClO_4 (C) anhydrous H_2SO_4 (D) anhydrous HNO_3
16. Which of the following behaves as a base in liquid HF?
(A) HOSO_3F (B) BF_3 (C) PF_5 (D) BrF_3
17. How many stereoisomeric forms of each of square-planar $[\text{PtCl}_2(\text{NH}_3)_2]$ and tetrahedral $[\text{NiCl}_2(\text{PPh}_3)_2]$ are there
(A) $[\text{PtCl}_2(\text{NH}_3)_2]$, two; $[\text{NiCl}_2(\text{PPh}_3)_2]$, two
(B) $[\text{PtCl}_2(\text{NH}_3)_2]$, two; $[\text{NiCl}_2(\text{PPh}_3)_2]$, one
(C) $[\text{PtCl}_2(\text{NH}_3)_2]$, one; $[\text{NiCl}_2(\text{PPh}_3)_2]$, one
(D) $[\text{PtCl}_2(\text{PPh}_3)_2]$, one; $[\text{NiCl}_2(\text{PPh}_3)_2]$, two
18. *Cis*- and *trans*-isomers of square planar $[\text{PtCl}_2(\text{PPh}_3)_2]$ can be distinguished by several methods. Which statement is **incorrect**?
(A) *cis*- $[\text{PtCl}_2(\text{PPh}_3)_2]$ has two IR active Pt–Cl stretching modes but *trans*- $[\text{PtCl}_2(\text{PPh}_3)_2]$ has only one
(B) In the ^{31}P NMR spectrum, the observed $J(^{31}\text{P}^{31}\text{P})$ for *trans*- $[\text{PtCl}_2(\text{PPh}_3)_2]$ is greater than that for *cis*- $[\text{PtCl}_2(\text{PPh}_3)_2]$
(C) The value of $J(^{31}\text{P}^{195}\text{Pt})$ for *cis*- $[\text{PtCl}_2(\text{PPh}_3)_2]$ is greater than that for *trans*- $[\text{PtCl}_2(\text{PPh}_3)_2]$
(D) X-ray crystallography would definitively distinguish between the isomers

19. Which of the following correctly places the metal centres in their order in the spectrochemical series?

- (A) Pd(II) < Ni(II) < Pt(IV)
(B) Co(III) < Co(II) < Rh(III)
(C) Pt(IV) < Pd(II) < Ni(II)
(D) Mn(II) < Fe(III) < Rh(III)

20. Which metal complex ion is expected to be subject to a Jahn-Teller distortion?

- (A) $[\text{Cr}(\text{OH}_2)_6]^{3+}$ (B) $[\text{Cr}(\text{NH}_3)_6]^{2+}$ (C) $[\text{Cr}(\text{CN})_6]^{3-}$ (D) $[\text{Cr}(\text{bpy})_3]^{2+}$

21. Scanning tunnelling microscopy (STM) could be used to reveal what features of a metal surface?

- (A) step-edges and adsorbed species
(B) elemental composition of the surface
(C) oxidation states of adsorbed atoms
(D) oxidation states of bulk and surface metal atoms

22. For which of the following might you use a Hoveyda-Grubbs' second generation catalyst?

- (A) alkene metathesis (B) hydroformylation (C) alkene hydrogenation (D) ethene epoxidation

23. The reactions of $[\text{PtCl}_4]^{2-}$ with NH_3 (reaction I) and of $[\text{PtCl}_4]^{2-}$ with $[\text{NO}_2]^-$ followed by NH_3 (reaction II) are ways of preparing:

- (A) I: *trans*- $[\text{PtCl}_2(\text{NH}_3)_2]$; II: *trans*- $[\text{PtCl}_2(\text{NH}_3)(\text{NO}_2)]^-$
(B) I: *cis*- $[\text{PtCl}_2(\text{NH}_3)_2]$; II: *trans*- $[\text{PtCl}_2(\text{NH}_3)(\text{NO}_2)]^-$
(C) I: *cis*- $[\text{PtCl}_2(\text{NH}_3)_2]$; II: *cis*- $[\text{PtCl}_2(\text{NH}_3)(\text{NO}_2)]^-$
(D) I: *trans*- $[\text{PtCl}_2(\text{NH}_3)_2]$; II: *cis*- $[\text{PtCl}_2(\text{NH}_3)(\text{NO}_2)]^-$

24. The first step in the Eigen-Wilkins mechanism for ML_6 undergoing Y for L substitution is:

- (A) loss of L
(B) addition of Y
(C) formation of a weakly bound encounter complex
(D) formation of a 7-coordinate complex in the rate-determining step

25. Match the structure type to the stated compound. Which pair is **incorrect**?
- (A) CoF_2 ; rutile structure type
 (B) TiO ; rock salt structure type
 (C) ZnS ; zinc blende structure type
 (D) FeF_2 ; anti-fluorite structure type
26. Which of the following is a π -donor ligand?
- (A) Cl^- (B) NH_3 (C) CO (D) PF_3
27. Match the M–M bond orders to the species given. Which pair is **incorrect**?
- (A) $[\text{Re}_2\text{Cl}_8]^{2-}$; Re–Re bond order = 4
 (B) $[\text{W}_2\text{Cl}_9]^{3-}$; W–W bond order = 3
 (C) $[\text{Mo}_2\text{Cl}_8]^{4-}$; Mo–Mo bond order = 4
 (D) $[\text{Os}_2\text{Cl}_8]^{2-}$; Os–Os bond order = 4
28. Which statement about organoaluminium compounds is **incorrect**?
- (A) Dimers of AlMe_3 possess delocalized Al–C–Al bonding interactions
 (B) The bonding in $\text{Al}_2\text{Me}_4\text{Cl}_2$ can be described in terms of a localized scheme
 (C) In $\text{Al}_2\text{Ph}_4(\mu\text{-C}\equiv\text{CPh})_2$, the bridge bonds can be described in a similar way to those in $\text{Al}_2\text{Me}_4(\mu\text{-Ph})_2$
 (D) $\text{Al}_2\{\text{CH}(\text{SiMe}_3)_2\}_4$ contains an Al–Al bond
29. Which statement is correct regarding the covalent bond classification (CBC)?
- (A) L is a 2-electron donor, Z is a 1-electron donor and X donates 0 electrons
 (B) L is a 2-electron donor, X is a 1-electron donor and Z donates 0 electrons
 (C) X is a 2-electron donor, Z is a 1-electron donor and L donates 0 electrons
 (D) Z is a 2-electron donor, L is a 1-electron donor and X donates 0 electrons

30. Which statement is **incorrect** about complexes formed by the lanthanoids?
- (A) Hard donor ligands are favored
(B) High coordination numbers are often observed
(C) The 4f atomic orbitals do not play a significant part in metal–ligand bonding
(D) Aqua ions are typically 6-coordinate
31. Band gaps affect semiconducting properties. Which is the correct ordering of band gaps in these III-V semiconductors?
- (A) GaSb < InSb (B) GaP > GaAs (C) InAs > InP (D) GaP < Si
32. Which statement correctly describes the function of cytochromes P-450?
- (A) Cytochromes P-450 act as monooxygenases and catalyze the insertion of O into a C–H bond
(B) Cytochromes P-450 couple to cytochrome c in the mitochondrial electron-transfer chain
(C) Cytochromes P-450 act as dioxygenases
(D) Cytochromes P-450 contain high-spin Fe(III); this directly binds O₂ and acts as an O₂ carrier
33. Enantiomers of [Cr(oxalate)₃]³⁻ are:
- (A) related by a rotation axis (B) diastereoisomers (C) structural isomers (D) stereoisomers
34. To compare the electronic absorption spectra of three iron(II) complexes, you want to combine the three spectra in one plot. You should plot:
- (A) extinction coefficient against wavelength
(B) absorbance against wavelength
(C) extinction coefficient against concentration
(D) absorbance against wavenumber
35. In an MO diagram for the formation of H₂O in which the z axis bisects the H–O–H angle and the molecular is on the xz plane:
- (A) the O 2p_z atomic orbital interacts with an in-phase combination of H 1s atomic orbitals
(B) the O 2p_y atomic orbital interacts with an out-of-phase combination of H 1s atomic orbitals
(C) the O 2p_x atomic orbital is non-bonding
(D) the O 2s atomic orbital is non-bonding

36. Which statement is **incorrect** about a cubic close-packed lattice?
- (A) All atoms have a coordination number of 12
(B) The lattice contains both tetrahedral and octahedral holes
(C) Layers of close-packed atoms are stacked in an ABABAB... pattern
(D) The packing is more efficient than in a body-centred cubic lattice
37. For the cell: $2\text{Ag}^+(\text{aq}) + \text{Zn}(\text{s}) \rightarrow 2\text{Ag}(\text{s}) + \text{Zn}^{2+}(\text{aq})$ $E^\circ_{\text{cell}} = 1.56 \text{ V}$
The value of ΔG° is:
- (A) $-150 \text{ kJ per mole of Zn}$
(B) $-602 \text{ kJ per mole of Ag}$
(C) $-301 \text{ kJ per mole of Ag}$
(D) $-301 \text{ kJ per mole of Zn}$
38. Comparing H_2O and NH_3 as solvents leads to analogies between which pair of species?
- (A) NH_3 and $[\text{OH}]^-$ (B) $[\text{NH}_2]^-$ and H_2O (C) $[\text{NH}_2]^-$ and $[\text{OH}]^-$ (D) $[\text{NH}_4]^+$ and H_2O
39. Match the compound formula to its application as a catalyst or catalyst precursor in the stated process.
Which pair is **incorrect**?
- (A) *cis*- $[\text{Rh}(\text{CO})_2\text{I}_2]^-$; Monsanto acetic acid synthesis
(B) $\text{RhCl}(\text{PPh}_3)_3$; alkene hydrogenation
(C) $\text{HRh}(\text{PPh}_3)_3$; asymmetric hydrogenation
(D) $\text{HCo}(\text{CO})_4$; hydroformylation of alkenes
40. The usual form of the experimental rate law for substitution in square planar Pt(II) complexes contains two terms:
- $$\text{Rate} = k_1[\text{PtL}_3\text{X}] + k_2[\text{PtL}_3\text{X}][\text{Y}]$$
- where PtL_3X is the starting complex and Y is the entering group. The reason for the two-term law is that:
- (A) there are competitive associative and dissociative pathways
(B) there are two competing dissociative pathways
(C) the solvent enters in the rate-determining step, and then two competing fast steps follow
(D) the solvent competes with Y in the rate-determining step

ABBREVIATIONS AND SYMBOLS			
amount of substance	<i>n</i>	Faraday constant	<i>F</i>
ampere	A	free energy	<i>G</i>
atmosphere	atm	frequency	ν
atomic mass unit	u	gas constant	<i>R</i>
Avogadro constant	N_A	gram	g
Celsius temperature	°C	hour	h
centi- prefix	c	joule	J
coulomb	C	kelvin	K
density	d	kilo- prefix	k
electromotive force	<i>E</i>	liter	L
energy of activation	E_a	measure of pressure mm Hg	
enthalpy	<i>H</i>	milli- prefix	m
entropy	<i>S</i>	molal	<i>m</i>
equilibrium constant	<i>K</i>	molar	<i>M</i>
		molar mass	<i>M</i>
		mole	mol
		Planck's constant	<i>h</i>
		pressure	<i>P</i>
		rate constant	<i>k</i>
		reaction quotient	<i>Q</i>
		second	s
		speed of light	<i>c</i>
		temperature, K	<i>T</i>
		time	<i>t</i>
		vapor pressure	VP
		volt	V
		volume	<i>V</i>

CONSTANTS
$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
$R = 0.08314 \text{ L bar mol}^{-1} \text{ K}^{-1}$
$F = 96,500 \text{ C mol}^{-1}$
$F = 96,500 \text{ J V}^{-1} \text{ mol}^{-1}$
$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
$h = 6.626 \times 10^{-34} \text{ J s}$
$c = 2.998 \times 10^8 \text{ m s}^{-1}$
$0^\circ\text{C} = 273.15 \text{ K}$
1 atm = 1.013 bar = 760 mm Hg
Specific heat capacity of $\text{H}_2\text{O} = 4.184 \text{ J g}^{-1} \text{ K}^{-1}$

EQUATIONS		
$E = E^\circ - \frac{RT}{nF} \ln Q$	$\ln K = \left(\frac{-\Delta H^\circ}{R} \right) \left(\frac{1}{T} \right) + \text{constant}$	$\ln \left(\frac{k_2}{k_1} \right) = \frac{E_a}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$

PERIODIC TABLE OF THE ELEMENTS

1 1A																			18 8A
1 H 1.008	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	2 He 4.003		
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18		
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95		
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80		
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3		
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)		
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (281)	111 Rg (272)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (294)	118 Og (294)		

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)