



CHEMISTRY
HIGHER LEVEL
PAPER 1

Tuesday 16 May 2000 (afternoon)

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.

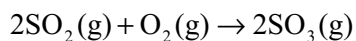
Periodic Table

1 H 1.01	Atomic Number Atomic Mass																2 He 4.00
3 Li 6.94	4 Be 9.01											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											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	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 95.94	43 Tc 98.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
55 Cs 132.91	56 Ba 137.34	57 † La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.21	77 Ir 192.22	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po (210)	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	109 Mt									

†	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 146.92	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
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‡	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)
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1. According to the equation:



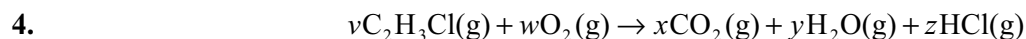
what volume of air (20 % O_2) is required to react with 10 dm^3 of SO_2 ?

- A. 2 dm^3
 - B. 5 dm^3
 - C. 10 dm^3
 - D. 25 dm^3
2. Which of the following compounds has the greatest **empirical** formula mass?
- A. C_6H_6
 - B. C_4H_{10}
 - C. C_3H_6
 - D. C_2H_6

3.
$$\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$$

When heated, CaCO_3 ($M_r = 100$) decomposes as shown above. When 20 g of impure CaCO_3 is heated, 0.15 moles of CO_2 are obtained. What is the percentage purity of the CaCO_3 ? (Assume that none of the impurities produce CO_2 upon heating.)

- A. 15
- B. 25
- C. 55
- D. 75



Chloroethene can be burned in oxygen as shown above. What is the value of w when $\nu = 2$?

- A. 2
- B. 3
- C. 4
- D. 5

5. Which of the following particles contain more electrons than **neutrons**?

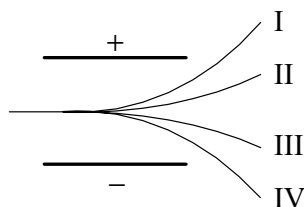
- I. ${}^1_1\text{H}$
- II. ${}^{35}_{17}\text{Cl}^-$
- III. ${}^{39}_{19}\text{K}^+$

- A. I only
- B. II only
- C. I and II only
- D. II and III only

6. The first four ionisation energies (kJ mol^{-1}) for a particular element are 550, 1064, 4210 and 5500 respectively. This element should be placed in the same Group as

- A. Li
- B. Be
- C. B
- D. C

7. A certain element with two isotopes of masses M and $M+2$ is introduced into a mass spectrometer, vaporised and ionised. Which of the following paths are most likely for the resulting ions?



M $M+2$

- | | | |
|----|----|-----|
| A. | I | IV |
| B. | II | I |
| C. | IV | III |
| D. | IV | II |
8. A certain element has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$. Which oxidation state(s) would this element most likely show?
- A. +2 only
- B. +3 only
- C. +2 and +5 only
- D. +2, +3, +4, +5
9. Which one of the following increases in value from Li to Cs?
- A. Atomic radius
- B. Electronegativity
- C. Ionisation energy
- D. Melting point

10. Which of the following chlorides give neutral solutions when added to water?

I. NaCl

II. Al_2Cl_6

III. PCl_3

A. I only

B. I and II only

C. II and III only

D. I, II and III

11. In which of the following is there at least one double bond?

I. O_2

II. CO_2

III. C_2H_4

A. I only

B. III only

C. II and III only

D. I, II and III

12. According to VSEPR theory, which molecule would be expected to have the **smallest** bond angle?

A. H_2O

B. H_2CO

C. CH_4

D. NH_3

13. Which of the following can exist in **both** polar and non-polar forms?

- A. CH_2Cl_2
- B. C_2HCl
- C. $\text{C}_2\text{H}_2\text{Cl}_2$
- D. $\text{C}_2\text{H}_3\text{Cl}$

14. What are the states of hybridisation for the carbon atoms in NCCH_2COOH ?

- | | CN | CH_2 | COOH |
|----|---------------|---------------|---------------|
| A. | sp | sp^3 | sp^2 |
| B. | sp | sp^2 | sp^3 |
| C. | sp^2 | sp^2 | sp^3 |
| D. | sp^2 | sp^3 | sp^2 |

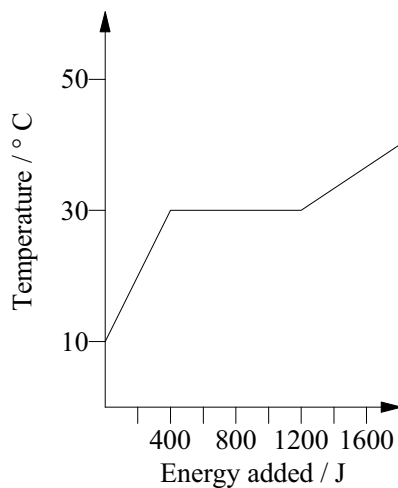
15. Which of the following best accounts for the observation that gases are easily compressed?

- A. Gas molecules have negligible attractive forces for one another.
- B. The volume occupied by the gas is much greater than that occupied by the molecules.
- C. The average energy of the molecules in a gas is proportional to the absolute temperature of the gas.
- D. The collisions between gas molecules are elastic.

16. Which expression represents the density of a gas sample of relative molar mass, M_r , at temperature, T , and pressure, P ?

- A. $\frac{PM_r}{T}$
- B. $\frac{RT}{PM_r}$
- C. $\frac{PM_r}{RT}$
- D. $\frac{RM_r}{PT}$

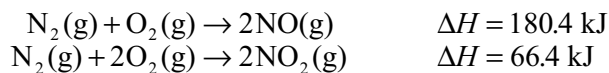
17.



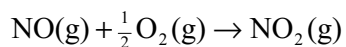
The heating curve for 10 g of a substance is given above. How much energy would be required to melt completely 20 g of the substance that is initially at 10° C?

- A. 2400 J
- B. 1200 J
- C. 800 J
- D. 400 J

18.



Use the enthalpy values above to calculate ΔH for the reaction;



- A. –57 kJ
- B. –114 kJ
- C. 57 kJ
- D. 114 kJ

19. In which reaction is the change in entropy (ΔS) closest to zero?

- A. $\text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{SO}_3(\text{g})$
- B. $\text{Br}_2(\text{l}) \rightarrow \text{Br}_2(\text{g})$
- C. $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightarrow 2\text{HI}(\text{g})$
- D. $3\text{Ca}(\text{s}) + \text{N}_2(\text{g}) \rightarrow \text{Ca}_3\text{N}_2(\text{s})$

20. The Born–Haber cycle for the formation of potassium chloride includes the steps below:

- I. $\text{K}(\text{g}) \rightarrow \text{K}^+(\text{g}) + \text{e}^-$
- II. $\frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{Cl}(\text{g})$
- III. $\text{Cl}(\text{g}) + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$
- IV. $\text{K}^+(\text{g}) + \text{Cl}^-(\text{g}) \rightarrow \text{KCl}(\text{s})$

Which of these steps are exothermic?

- A. I and II only
- B. III and IV only
- C. I, II and III only
- D. I, III and IV only

21. Some collisions between reactant molecules do not form products. This is most likely because

- A. the molecules do not collide in the proper ratio.
- B. the molecules do not have enough energy.
- C. the concentration is too low.
- D. the reaction is at equilibrium.

22. Doubling which one of the following will double the rate of a first order reaction?

- A. Concentration of the reactant
- B. Size of solid particles
- C. Volume of solution in which the reaction is carried out
- D. Activation energy

23.
$$\text{F}_2(\text{g}) + 2\text{ClO}_2(\text{g}) \rightarrow 2\text{FClO}_2(\text{g})$$

The following data were obtained for the reaction above. Use these data to determine the orders for the reactants F_2 and ClO_2 .

$[\text{F}_2(\text{g})] / \text{mol dm}^{-3}$	$[\text{ClO}_2(\text{g})] / \text{mol dm}^{-3}$	Rate / $\text{mol dm}^{-3} \text{s}^{-1}$
0.1	0.01	1.2×10^{-3}
0.1	0.04	4.8×10^{-3}
0.2	0.01	2.4×10^{-3}

Order of reaction

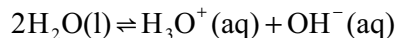
	F_2	ClO_2
A.	1	1
B.	1	2
C.	2	1
D.	2	4

24.
$$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H = -197.8 \text{ kJ}$$

The reaction above is an important step in the production of sulfuric acid. An increase in which of the following will increase the ratio of $\frac{\text{SO}_3(\text{g})}{\text{SO}_2(\text{g})}$ at equilibrium?

- A. Pressure only
- B. Temperature only
- C. Both temperature and pressure
- D. Neither pressure nor temperature

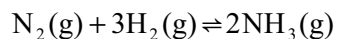
25.



The equilibrium constant for the reaction above is 1.0×10^{-14} at 25°C and 2.1×10^{-14} at 35°C . What can be concluded from this information?

- A. $[\text{H}_3\text{O}^+]$ decreases as the temperature is raised.
- B. $[\text{H}_3\text{O}^+]$ is greater than $[\text{OH}^-]$ at 35°C .
- C. Water is a stronger electrolyte at 25°C .
- D. The ionisation of water is endothermic.

26.

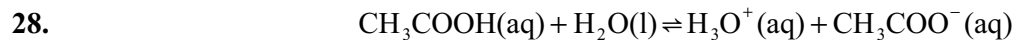


What is the equilibrium expression for the reaction above?

- A. $K_c = \frac{[\text{NH}_3]}{[\text{N}_2][\text{H}_2]}$
- B. $K_c = \frac{2[\text{NH}_3]}{[\text{N}_2][\text{H}_2]}$
- C. $K_c = \frac{2[\text{NH}_3]}{3[\text{N}_2][\text{H}_2]}$
- D. $K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$

27. 10 cm^3 of an HCl solution with a pH value of 2 was mixed with 90 cm^3 of water. What will be the pH of the resulting solution?

- A. 1
- B. 3
- C. 5
- D. 7



In the equilibrium above, what are the two conjugate bases?

- A. CH_3COOH and H_2O
- B. CH_3COO^- and H_3O^+
- C. CH_3COOH and H_3O^+
- D. CH_3COO^- and H_2O

29. Which of the following is the weakest acid in aqueous solution?

- A. $\text{C}_6\text{H}_5\text{OH}$ $K_a = 1.3 \times 10^{-10}$
- B. HCN $K_a = 4.9 \times 10^{-10}$
- C. H_2Se $K_a = 1.5 \times 10^{-4}$
- D. HF $K_a = 6.9 \times 10^{-4}$

30. Which salt will produce the most alkaline solution when dissolved in water?

- A. KNO_3
- B. MgCl_2
- C. $\text{CH}_3\text{CO}_2\text{Na}$
- D. $(\text{NH}_4)_2\text{SO}_4$

31. In the electrolysis of molten sodium chloride, the sodium ion goes to the

- A. positive electrode where it undergoes oxidation.
- B. negative electrode where it undergoes oxidation.
- C. positive electrode where it undergoes reduction.
- D. negative electrode where it undergoes reduction.

32. Which one of the following could reduce $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ to $\text{Cr}^{3+}(\text{aq})$?

- A. $\text{Ca}^{2+}(\text{aq})$
- B. $\text{Cu}^{2+}(\text{aq})$
- C. $\text{Fe}^{2+}(\text{aq})$
- D. $\text{Zn}^{2+}(\text{aq})$

33.
$$\begin{array}{ll} \text{Tl}^+(\text{aq}) + \text{e}^- \rightarrow \text{Tl}(\text{s}) & E^\ominus = -0.336 \text{ V} \\ \text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s}) & E^\ominus = 0.339 \text{ V} \end{array}$$

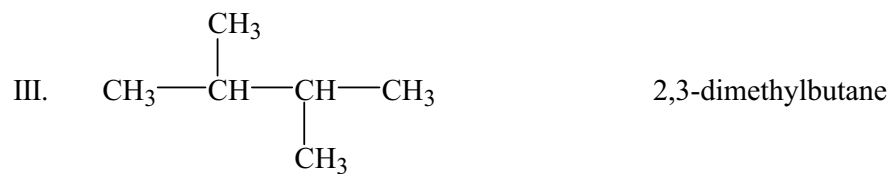
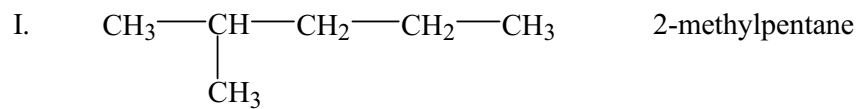
The standard electrode potentials for two metals are given above. What are the equation and cell potential for the spontaneous reaction that occurs?

- A. $\text{Tl}^+(\text{aq}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Tl}(\text{s}) + \text{Cu}(\text{s})$ $E^\ominus = 0.003 \text{ V}$
- B. $2\text{Tl}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \rightarrow 2\text{Tl}^+(\text{aq}) + \text{Cu}(\text{s})$ $E^\ominus = 0.675 \text{ V}$
- C. $2\text{Tl}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \rightarrow 2\text{Tl}^+(\text{aq}) + \text{Cu}(\text{s})$ $E^\ominus = 1.011 \text{ V}$
- D. $2\text{Tl}^+(\text{aq}) + \text{Cu}(\text{s}) \rightarrow 2\text{Tl}(\text{s}) + \text{Cu}^{2+}(\text{aq})$ $E^\ominus = 0.333 \text{ V}$

34. When molten magnesium chloride is electrolysed, how many moles of gaseous chlorine will be produced for every mole of magnesium?

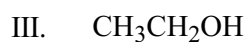
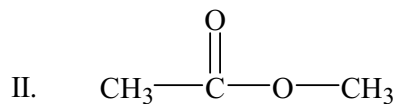
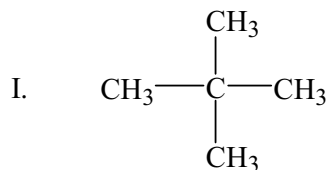
- A. $\frac{1}{2}$
- B. 1
- C. 2
- D. 4

35. Which names are correct for the following isomers of C_6H_{14} ?



- A. I only
- B. I and II only
- C. I and III only
- D. I, II and III

36. Which of the compounds below will show a single peak in its $^1\text{H-NMR}$ spectrum?



- A. I only
- B. III only
- C. I and II only
- D. I, II and III

37. What is the correct order of reaction types in the following sequence?

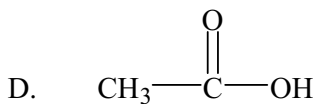
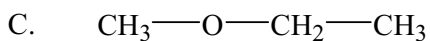
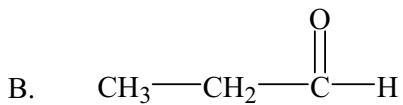
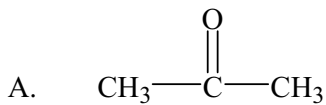


- | | I | II | III |
|----|--------------|--------------|----------------|
| A. | substitution | oxidation | esterification |
| B. | addition | substitution | substitution |
| C. | oxidation | substitution | addition |
| D. | substitution | oxidation | substitution |

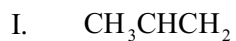
38. Which carbon-containing product is most likely from the reaction of C_2H_4 and Br_2 ?

- A. $\text{C}_2\text{H}_5\text{Br}$
- B. $\text{C}_2\text{H}_4\text{Br}_2$
- C. $\text{C}_2\text{H}_3\text{Br}$
- D. $\text{C}_2\text{H}_2\text{Br}_2$

39. Which of the following is expected to be a gas at 25° C?



40. Which of the compounds below is/are more likely to undergo substitution, rather than addition, reactions?



A. I only

B. II only

C. I and III only

D. II and III only