

Chemistry
Higher level
Paper 1

Friday 13 November 2015 (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.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[40 marks]**.

The Periodic Table

1 2 3 4 5 6 7 0

Atomic number		Element										Relative Atomic Mass			
1	H 1.01	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
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
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
87	Fr (223)	88	Ra (226)	89 ‡	Ac (227)	77	Ir 192.22	78	Pt 195.09	79	Au 196.97	80	Hg 200.59	81	Tl 204.37
						27	Co 58.93	28	Ni 58.71	29	Cu 63.55	30	Zn 65.37	31	Ga 69.72
						28	Ni 58.71	45	Rh 102.91	46	Pd 106.42	47	Ag 107.87	48	Cd 112.40
						45	Rh 102.91	51	Sb 121.75	52	Te 127.60	53	I 126.90	54	Xe 131.30
						51	Sb 121.75	82	Pb 207.19	83	Bi 208.98	84	Po (210)	85	At (210)
						82	Pb 207.19	204.37	Tl 204.37	200.59	Hg 200.59	208.98	Bi 208.98	210	Po (210)

†

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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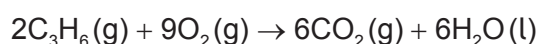
‡

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. Which compound's molecular formula is the same as its empirical formula?

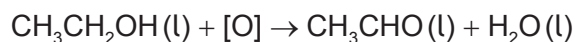
- A. C_2H_5OH
- B. CH_3COOH
- C. C_6H_6
- D. C_8H_{18}

2. The equation for the **complete** combustion of propene, C_3H_6 , is shown below.



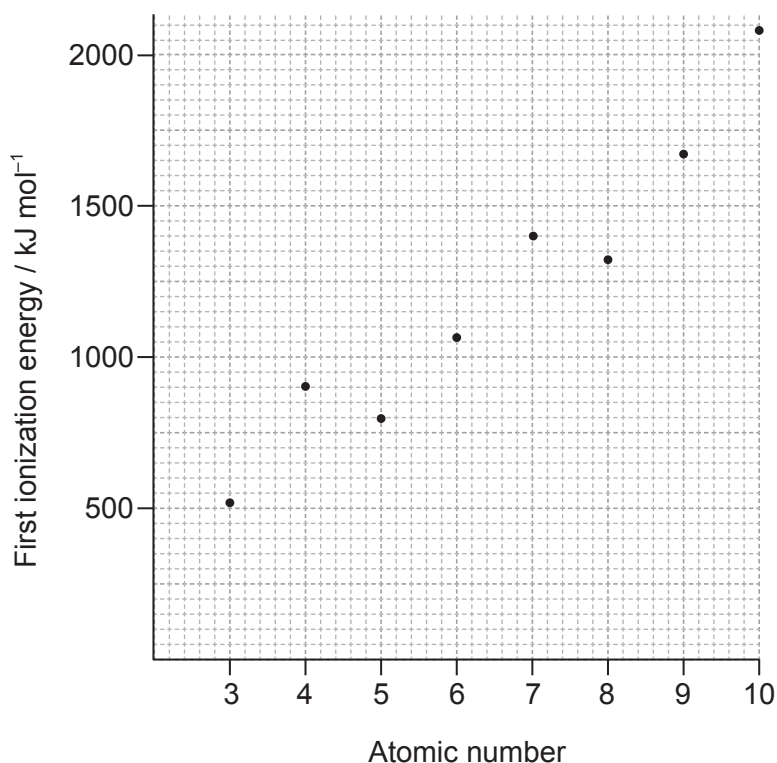
Which mixture, when ignited, will lead to **incomplete** combustion and the formation of $CO(g)$?

- A. 2 dm^3 of propene and 10 dm^3 of oxygen
 - B. 0.5 dm^3 of propene and 2.3 dm^3 of oxygen
 - C. 1 dm^3 of propene and 4 dm^3 of oxygen
 - D. 3 dm^3 of propene and 14 dm^3 of oxygen
3. What is the percentage yield when 1.1 g of ethanal, CH_3CHO , is obtained from 4.6 g of ethanol, CH_3CH_2OH ? $M_r(CH_3CH_2OH) = 46$; $M_r(CH_3CHO) = 44$



- A. $\frac{1.1 \times 46 \times 100}{44 \times 4.6}$
- B. $\frac{1.1 \times 100}{4.6}$
- C. $\frac{4.6 \times 44 \times 100}{4.6 \times 1.1}$
- D. $\frac{1.1 \times 46}{44 \times 4.6}$

4. Which stage of operation immediately follows ionization in the mass spectrometer?
- Acceleration
 - Deflection
 - Detection
 - Vaporization
5. Which statement is correct about the first ionization energies of consecutive elements shown in the graph?



[Source: Values from Nuffield Advance Science - Book of Data, Revised Edition (1984)]

- The graph falls between Be and B because there is an electron in the third energy level.
- The graph increases from B to N because the atomic radius is increasing.
- The graph increases from Li to Ne because the number of electrons is increasing.
- The graph falls between Be and B because the outer electron in B is in a p sub-level.

6. Which element has the greatest first ionization energy?
- A. Al
 - B. Ar
 - C. Cl
 - D. Cs
7. Which elements are in the same group of the periodic table?
- A. Ca, Na, Rb, Sr
 - B. Al, Ar, Cl, S
 - C. Au, Hg, Pb, Pt
 - D. As, Bi, P, Sb
8. Which property of transition metals enables them to behave as catalysts?
- A. High melting point
 - B. Variable oxidation number
 - C. High density
 - D. Split d sub-levels
9. Which statement best describes the lattice structure of solid sodium chloride?
- A. Each sodium ion is surrounded by one chloride ion.
 - B. Each chloride ion is surrounded by two sodium ions.
 - C. Each chloride ion is surrounded by four sodium ions.
 - D. Each sodium ion is surrounded by six chloride ions.
10. Which compound is most likely to contain ionic bonding?
- A. ClO_2
 - B. CsCl
 - C. SCl_2
 - D. SiCl_4

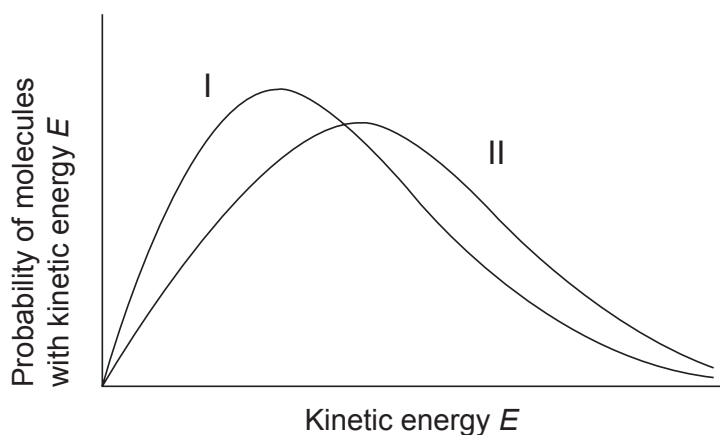
11. Which molecule is polar?
- A. C_2H_6
 - B. CH_2Cl_2
 - C. CO_2
 - D. CCl_4
12. What is the shape of the hexacyanoferrate(III) ion, $[Fe(CN)_6]^{3-}$?
- A. Square planar
 - B. Hexagonal
 - C. Octahedral
 - D. Trigonal bipyramidal
13. Which set contains two or more species with delocalized π electrons?
- A. CH_3CH_3 , $H_2C=CH_2$, $H_2C=O$
 - B. $NaCl$, C_6H_6 , $H_2C=O$
 - C. CO_3^{2-} , C_6H_6 , C_6H_{12}
 - D. O_2 , CH_3COCH_3 , CH_3COOCH_3
14. Which of the following changes are exothermic?
- I. $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$
 - II. $2C_8H_{18}(g) + 17O_2(g) \rightarrow 16CO(g) + 18H_2O(g)$
 - III. $C_8H_{18}(g) \rightarrow C_8H_{18}(l)$
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

15. Which change represents the standard enthalpy change of formation?
- The formation of 1 mol of a compound in its standard state from its gaseous atoms
 - The formation of 1 mol of a compound in its standard state from its elements
 - The formation of 1 mol of a compound in its standard state from its gaseous atoms in their standard states
 - The formation of 1 mol of a compound in its standard state from its elements in their standard states
16. Which equation represents electron affinity?
- $C(g) + e^- \rightarrow C^-(g)$
 - $Na^+(aq) + e^- \rightarrow Na(s)$
 - $\frac{1}{2}Cl_2(g) + e^- \rightarrow Cl^-(g)$
 - $B(g) + e^- \rightarrow B^+(g) + 2e^-$
17. Which combination results in an ionic compound having the **greatest** magnitude of lattice enthalpy?

	Sum of ionic radii	Ionic charges
A.	small	large
B.	large	large
C.	large	small
D.	small	small

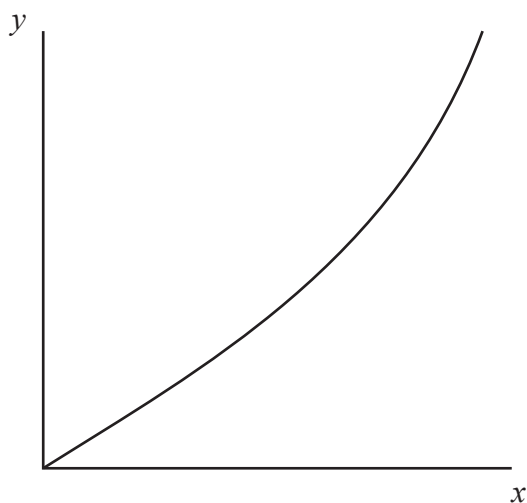
18. Under which conditions does a sample of the same mass of carbon dioxide have the **lowest** entropy value?
- Solid at high temperature
 - Solid at low temperature
 - Gas at high temperature
 - Gas at low temperature

19. Curves I and II represent samples of the same gas at a constant pressure but at different temperatures. The areas under curves I and II are equal. What does curve II represent?



- A. Curve II is at the lower temperature and there are less molecules in the sample.
- B. Curve II is at the lower temperature and there are the same number of molecules in the samples.
- C. Curve II is at the higher temperature and there are more molecules in the sample.
- D. Curve II is at the higher temperature and there are the same number of molecules in the samples.

20. The graph shows a plot for a reaction with second-order kinetics. How should the axes be labelled?



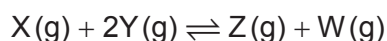
	x-axis	y-axis
A.	concentration	time
B.	time	concentration
C.	rate	concentration
D.	concentration	rate

21. Which factors affect the rate constant, k , of a reaction?

- I. Catalyst
 - II. Concentration of reactants
 - III. Temperature
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

22. Which best describes a reaction in a state of equilibrium?
- A. The rates of the forward and reverse reactions are zero and the concentrations of products and reactants are equal.
 - B. The rate of the forward reaction equals the rate of the reverse reaction and the concentrations of products and reactants are equal.
 - C. The rates of the forward and reverse reactions are zero and the concentrations of products and reactants are constant.
 - D. The rate of the forward reaction equals the rate of the reverse reaction and the concentrations of products and reactants are constant.

23. The equilibrium concentrations of X, Y, Z and W are 1, 2, 4 and 2 mol dm⁻³ respectively.



What is the value of the equilibrium constant, K_c ?

- A. 0.25
 - B. 0.5
 - C. 2
 - D. 4
24. Which of the following molecules can act as a Lewis acid but not as a Brønsted–Lowry acid?
- A. BF₃
 - B. PCl₃
 - C. NH₃
 - D. H₂O
25. Which is a 0.001 mol dm⁻³ solution of a weak acid?

	Conductivity	pH
A.	poor	5
B.	good	7
C.	poor	10
D.	good	3

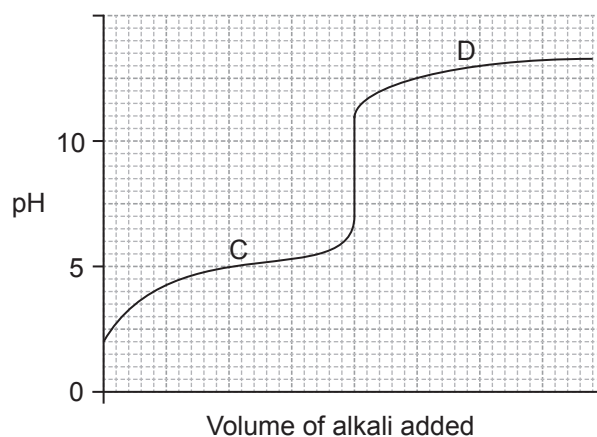
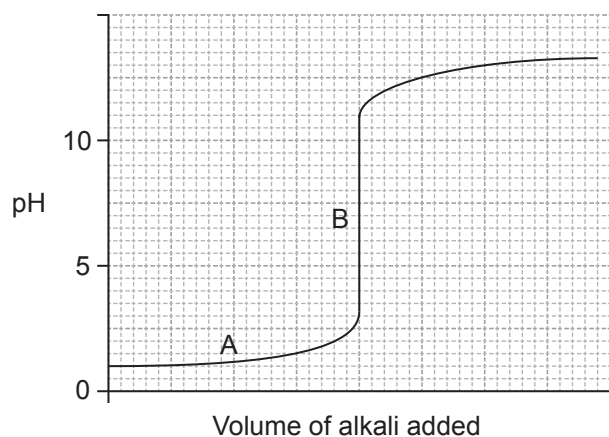
26. What is the order of increasing acid strength? Approximate K_a and pK_a values at 298 K are given.

	K_a		pK_a
ClCH_2COOH	1×10^{-3}	$\text{C}_6\text{H}_5\text{OH}$	10.0
$\text{CH}_3\text{CH}_2\text{COOH}$	1×10^{-5}	$\text{C}_6\text{H}_5\text{NH}_3^+$	4.6

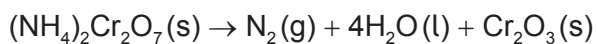
- A. $\text{ClCH}_2\text{COOH} < \text{CH}_3\text{CH}_2\text{COOH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{C}_6\text{H}_5\text{OH}$
- B. $\text{C}_6\text{H}_5\text{OH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{ClCH}_2\text{COOH} < \text{CH}_3\text{CH}_2\text{COOH}$
- C. $\text{C}_6\text{H}_5\text{OH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{CH}_3\text{CH}_2\text{COOH} < \text{ClCH}_2\text{COOH}$
- D. $\text{C}_6\text{H}_5\text{OH} < \text{CH}_3\text{CH}_2\text{COOH} < \text{C}_6\text{H}_5\text{NH}_3^+ < \text{ClCH}_2\text{COOH}$
27. Which solutions, mixed in equal concentrations and volumes, form an acid buffer solution?
- A. $\text{HCl}(\text{aq}) + \text{NaCl}(\text{aq})$
- B. $\text{CH}_3\text{CO}_2\text{H}(\text{aq}) + \text{CH}_3\text{CO}_2\text{Na}(\text{aq})$
- C. $\text{CH}_3\text{CO}_2\text{H}(\text{aq}) + \text{NaOH}(\text{aq})$
- D. $\text{CH}_3\text{CO}_2\text{H}(\text{aq}) + \text{CH}_3\text{CH}_2\text{CO}_2\text{H}(\text{aq})$
28. Which salt forms the most acidic solution when dissolved in water?

	Salt	Ionic radius of cation / 10^{-12} m
A.	CrCl_3	63
B.	FeCl_2	76
C.	MgCl_2	65
D.	NaCl	98

29. What is the buffer region in the acid–base titration curves below?



30. Which element undergoes reduction in the following reaction?

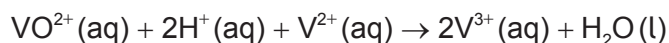


- A. Cr
- B. H
- C. N
- D. O

31. Which best describes reduction?

- A. Increase in oxidation number and gain of electrons
- B. Increase in oxidation number and loss of electrons
- C. Decrease in oxidation number and gain of electrons
- D. Decrease in oxidation number and loss of electrons

32. What is E^\ominus , in V, for the following reaction?

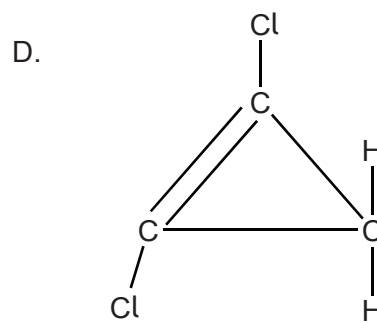
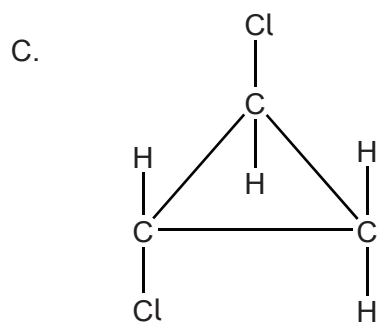
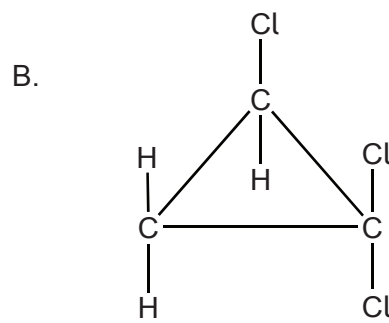
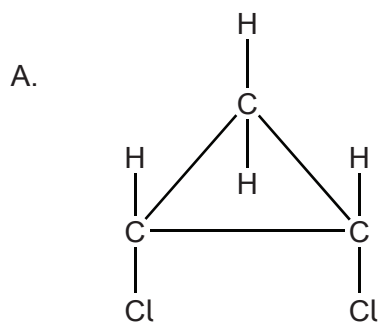


	Standard electrode potential, E^\ominus / V
$\text{V}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{V}(\text{s})$	-1.18
$\text{V}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{V}^{2+}(\text{aq})$	-0.26
$\text{VO}^{2+}(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{V}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+0.34
$\text{VO}_2^+(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{VO}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+1.00

- A. -0.60
- B. +0.08
- C. +0.60
- D. +1.26
33. What product is formed at the positive electrode (anode) when $0.001 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4(\text{aq})$ is electrolysed?
- A. Hydrogen
- B. Oxygen
- C. Sulfur
- D. Sulfur dioxide
34. Which pair of compounds can be distinguished by reacting them with dilute bromine water in the dark?
- A. $\text{CH}_3\text{CH}_2\text{COOH}$ and $\text{CH}_3\text{CH}_2\text{CHO}$
- B. $\text{CH}_3\text{CH}_2\text{CHCHCH}_3$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- C. $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)_2$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHBrCH}_3$ and $\text{CH}_3\text{CH}_2\text{CHBrCH}_2\text{CH}_3$

35. Which compound is most soluble in water?
- A. $\text{CH}_3\text{CH}_2\text{CHO}$
 - B. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
 - C. $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
 - D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$
36. Which are features of successive members of a homologous series?
- I. Similar chemical properties
 - II. Same general formula
 - III. Differ by $-\text{CH}_2-$
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
37. Which formula represents propanenitrile?
- A. $\text{CH}_3\text{CH}_2\text{CN}$
 - B. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$
 - C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$
 - D. $\text{CH}_3\text{CH}(\text{NH}_2)\text{CH}_3$
38. Which halogenoalkane reacts fastest with warm $\text{NaOH}(\text{aq})$?
- A. $(\text{CH}_3)_3\text{CCl}$
 - B. $(\text{CH}_3)_3\text{CBr}$
 - C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$
 - D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$

39. Which is the geometric isomer of *cis*-1,2-dichlorocyclopropane?



40. Which is the best-fit line or best-fit curve for the points plotted on the graph?

