Teacher: .....

NAME: _____

CANDIDATE SESSION NUMBER

0	2	5	0	1	2				

EXAMINATION CODE

8	8	2	2	-	6	1	0	1

ST JOSEPH'S INSTITUTION
Y6 PRELIMINARY EXAMINATION 2022

CHEMISTRY
HIGHER LEVEL
PAPER 1
Friday

12 August 2022
1 hour
0800 – 0900 h

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Write your teacher's name on the top right-hand corner of the question paper.
- 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]*.

This question paper consists of **16** printed pages including the Cover Sheet.

[Turn over]

The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.01				Atomic number / Element / Relative atomic mass													2 He 4.00
2	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
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.90
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 † La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 ‡ Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (269)	109 Mt (278)	110 Ds (281)	111 Rg (281)	112 Cn (285)	113 Unt (286)	114 Uuq (289)	115 Uup (288)	116 Uuh (293)	117 Uus (294)	118 Uuo (294)

†	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
‡	90 Th 232.04	91 Pa 231.04	92 U 238.03	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)

1. How much ethanol contains 1.20×10^{24} atoms of carbon?

Avogadro's constant, L or N_A: 6.02×10^{23} mol^{-1}

A. 0.333 mol

B. 0.500 mol

C. 1.00 mol

D. 2.00 mol

2. 3.00 mol of C_3H_8 is mixed with 20.00 mol of O_2. Which quantity is present at the end of the reaction?

$$C_3H_8\,(g) + 5O_2\,(g) \rightarrow 3CO_2\,(g) + 4H_2O\,(g)$$

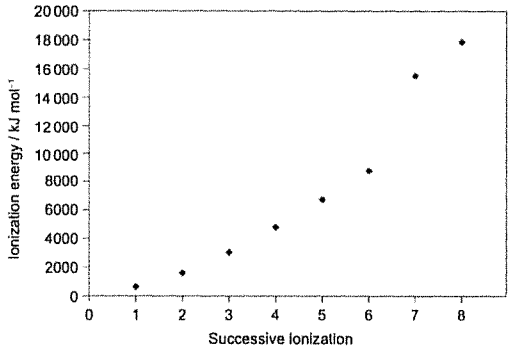
A. 1.00 mol of C_3H_8

B. 5.00 mol of O_2

C. 12.00 mol of CO_2

D. 16.00 mol of H_2O

3. The first eight successive ionization energies for an element are shown. In which group is the element?



A. 6

B. 7

C. 8

D. 17

4. Which ion has the largest radius?

A. Na^+

B. Mg^{2+}

C. P^{3-}

D. S^{2-}

5. Which is a d-block element?

A. Ca

B. Cf

C. Cl

D. Co

6. Which factor does not affect the colour of a complex ion?

A. temperature of the solution

B. identity of the ligand

C. identity of the metal

D. oxidation number of the metal

7. Which substance is most likely to be ionic?

	Melting point	Solubility in hexane	Electrical conductivity of solid
A.	High	Low	High
B.	Low	Low	Low
C.	Low	High	Low
D.	High	Low	Low

8. Which compound has the shortest C to N bond?

A. HCN

B. $CH_3CH_2NH_2$

C. CH_3CHNH

D. $(CH_3)_2NH$

9. What is the electron domain geometry of Si in SiO_2?

A. bent

B. linear

C. square planar

D. tetrahedral

10. The following compounds have similar relative molecular masses. What is the order of increasing boiling point?

A. $CH_3CH_2CH_2OH < CH_3CH_2CHO < CH_3COOH$

B. $CH_3CH_2CHO < CH_3CH_2CH_2OH < CH_3COOH$

C. $CH_3CH_2CHO < CH_3COOH < CH_3CH_2CH_2OH$

D. $CH_3COOH < CH_3CH_2CHO < CH_3CH_2CH_2OH$

11. Which contain delocalised electrons?

I. C_6H_5OH
II. CH_3COO^-
III. Cu

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

12. Which atom has an expanded octet?

A. C in CO_2

B. S in SCl_4

C. O in H_2O_2

D. P in PCl_3

13. What is the hybridization of nitrogen and chlorine in NCl_3?

	N	Cl
A.	sp^2	sp^2
B.	sp^2	sp^3
C.	sp^3	sp^2
D.	sp^3	sp^3

14. What is the enthalpy change, **in J**, when 5 g of water is heated from 10 °C to 18 °C?

Specific heat capacity of water: 4.18 kJ kg^{-1} K^{-1}

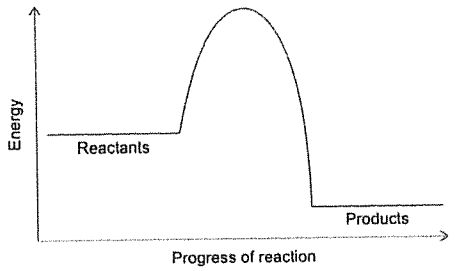
A. $5 \times 4.18 \times 8$

B. $5 \times 10^{-3} \times 4.18 \times 8$

C. $5 \times 4.18 \times (273 + 8)$

D. $5 \times 10^{-3} \times 4.18 \times (273 + 8)$

15. The potential energy profile of a reaction is shown.



What can be determined about stability and energy change from the potential energy profile shown?

	More stable	Reaction
A.	reactants	exothermic
B.	reactants	endothermic
C.	products	exothermic
D.	products	endothermic

16. Which equation represents the standard enthalpy of formation of lithium oxide?

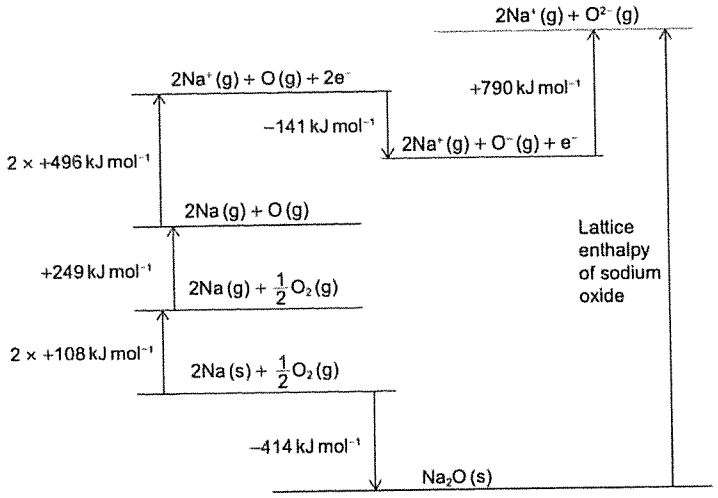
A. $4Li\,(s) + O_2\,(g) \rightarrow 2Li_2O\,(s)$

B. $2Li\,(s) + \frac{1}{2}O_2\,(g) \rightarrow Li_2O\,(s)$

C. $Li\,(s) + \frac{1}{4}O_2\,(g) \rightarrow \frac{1}{2}Li_2O\,(s)$

D. $Li\,(g) + \frac{1}{4}O_2\,(g) \rightarrow \frac{1}{2}Li_2O\,(g)$

17. Consider the Born–Haber cycle for the formation of sodium oxide:



What is the lattice enthalpy, in kJ mol^{-1}, of sodium oxide?

A. $414 + 2(108) + 249 + 2(496) - 141 + 790$

B. $414 + 2(108) + 249 + 2(496) + 141 + 790$

C. $-414 + 2(108) + 249 + 2(496) - 141 + 790$

D. $-414 - 2(108) - 249 - 2(496) + 141 - 790$

18. Which change results in the largest negative value of ΔS?

A. $C_2H_5OH\,(l) + SOCl_2\,(l) \rightarrow C_2H_5Cl\,(l) + SO_2\,(g) + HCl\,(g)$

B. $CaCO_3\,(s) \rightarrow CaO\,(s) + CO_2\,(g)$

C. $H_2O\,(l) \rightarrow H_2O\,(s)$

D. $NH_3\,(g) + HCl\,(g) \rightarrow NH_4Cl\,(s)$

19. Which combination has the greatest rate of reaction at room temperature?

	Zinc	$CuSO_4(aq)$
A.	1.00 g Zn powder	50.0 cm^3 of 0.200 mol dm^{-3} $CuSO_4(aq)$
B.	1.00 g Zn powder	100.0 cm^3 of 0.100 mol dm^{-3} $CuSO_4(aq)$
C.	1.00 g Zn strip	50.0 cm^3 of 0.200 mol dm^{-3} $CuSO_4(aq)$
D.	1.00 g Zn strip	100.0 cm^3 of 0.100 mol dm^{-3} $CuSO_4(aq)$

20. A reaction proceeds by the following mechanism:

step 1: $A + A \rightarrow B$
step 2: $B + C \rightarrow D$

Which rate equation is consistent with this mechanism?

A. Rate = $k[B]^2[C]$

B. Rate = $k[A]^2[B][C]$

C. Rate = $k[A]^2$

D. Rate = $k[A][C]$

21. A reversible reaction has a reaction quotient, Q, of 5.2×10^{-2} and equilibrium constant K_c, of 3.5×10^{-3}.

$$2A\,(g) \rightleftharpoons A_2\,(g)$$

Which statement describes the reaction at this time?

A. The system has reached equilibrium.

B. The rate of the forward reaction is less than the rate of the reverse reaction.

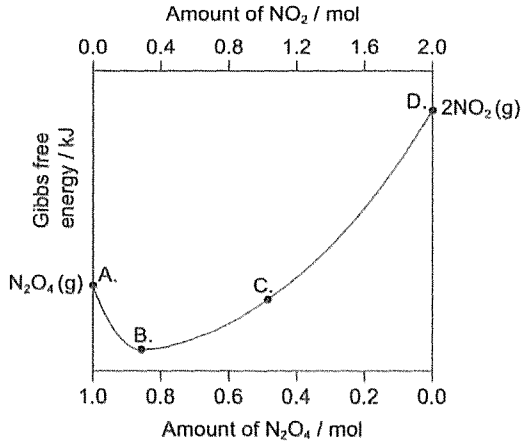
C. The concentration of reactant is less than the concentration of product.

D. At equilibrium, the concentration of reactant is less than the concentration of product.

22. The graph shows the Gibbs free energy of a mixture of N_2O_4 (g) and NO_2 (g) in different proportions.

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g)$$

Which point shows the system at maximum entropy?



23. Which is amphiprotic?

A. SO_4^{2-}

B. H_3O^+

C. $H_2PO_4^-$

D. NH_4^+

24. Which solution has a pH of 10?

A. 1.0×10^{-10} mol dm^{-3} HCl (aq)

B. 1.0×10^{-4} mol dm^{-3} KOH (aq)

C. 1.0×10^{-10} mol dm^{-3} KOH (aq)

D. 1.0×10^{-4} mol dm^{-3} HCl (aq)

25. Which is a Lewis acid, but not a Brønsted-Lowry acid?

A. $BeCl_2$

B. H_3O^+

C. NH_3

D. O^{2-}

26. What is correct for pure cold water?

	pH	$[H^+]$ and $[OH^-]$
A.	exactly 7	$[H^+] = [OH^-]$
B.	below 7	$[H^+] = [OH^-]$
C.	above 7	$[H^+] < [OH^-]$
D.	above 7	$[H^+] = [OH^-]$

27. What is a possible value of pH at the equivalence point in the titration of a weak acid with a strong base?

A. 3

B. 5

C. 7

D. 9

28. What is the change in the oxidation state of oxygen?

$$2Fe^{2+}\,(aq) + H_2O_2\,(aq) + 2H^+\,(aq) \rightarrow 2H_2O\,(l) + 2Fe^{3+}\,(aq)$$

A. +1

B. 0

C. -1

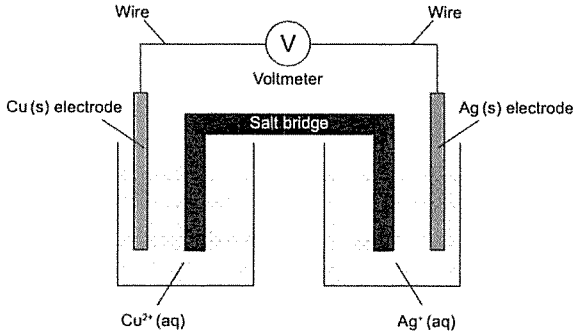
D. -2

29. What is correct for this redox reaction?

$$MnO_2\,(s) + 2I^-\,(aq) + 4H^+\,(aq) \rightarrow Mn^{2+}\,(aq) + I_2\,(aq) + 2H_2O\,(l)$$

	Reduced	Reducing Agent
A.	MnO_2 (s)	I^- (aq)
B.	I^- (aq)	H^+ (aq)
C.	I^- (aq)	MnO_2 (s)
D.	H^+ (aq)	I^- (aq)

30. Consider this voltaic cell, where Cu is a more reactive metal than Ag:



Which combination describes the movement of charge in this cell?

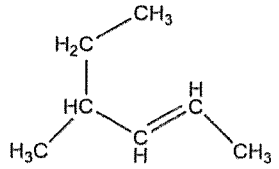
	Flow of electrons in wire	Flow of positive ions in salt bridge
A.	Ag (s) to Cu (s)	Towards Ag^+ (aq)
B.	Cu (s) to Ag (s)	Towards Ag^+ (aq)
C.	Ag (s) to Cu (s)	Towards Cu^{2+} (aq)
D.	Cu (s) to Ag (s)	Towards Cu^{2+} (aq)

31. Which gives the equation and cell potential of the spontaneous reaction?

	$E^{\ominus}$ / V
$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$	−1.18
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80

		$E^{\ominus}$ / V
A.	$Mn^{2+}(aq) + 2Ag(s) \rightarrow Mn(s) + 2Ag^+(aq)$	-1.98
B.	$Mn^{2+}(aq) + 2Ag(s) \rightarrow Mn(s) + 2Ag^+(aq)$	+0.38
C.	$Mn(s) + 2Ag^+(aq) \rightarrow Mn^{2+}(aq) + 2Ag(s)$	-0.38
D.	$Mn(s) + 2Ag^+(aq) \rightarrow Mn^{2+}(aq) + 2Ag(s)$	+1.98

32. What is the name of this compound, applying IUPAC rules?



A. 4-methylhex-2-ene

B. 4-ethylpent-2-ene

C. 2-ethylpent-3-ene

D. 3-methylhex-4-ene

33. What is formed in a propagation step of the substitution reaction between bromine and ethane?

A. $CH_3CH_2\bullet$

B. $CH_3CH_2CH_2CH_3$

C. $H\bullet$

D. Br^-

34. Which product is formed when $CH_3COCH_2CH_3$ is reduced with sodium borohydride?

A. $CH_3CH_2CH_2CHO$

B. $CH_3CH_2CH_2CH_2OH$

C. $CH_3CH(OH)CH_2CH_3$

D. $CH_3CH_2CH_2COOH$

35. Which is most likely to hydrolyse via a S_N1 mechanism?

A. $CH_3CHBrCH_2CH_3$

B. $(CH_3)_2CHBr$

C. $(CH_3)_3CBr$

D. $CH_3CH_2CH_2CH_2Br$

36. Which statement is true about conformational isomers?

A. They are non-superimposeable mirror images of each other.

B. They have the same molecular formula but different arrangements of atoms.

C. They interconvert only by breaking and reforming a bond.

D. They interconvert by rotation about a σ bond.

37. Which compound rotates the plane of plane-polarized light?

A. $CH_3C(CH_3)ClCH_3$

B. $CH_3CH_2CHClCH_3$

C. $CH_3C(Cl)_2CH_3$

D. $CH_3CClBrCH_3$

38. Burette readings for a titration are shown.

Burette readings / $cm^3 \pm 0.05 cm^3$	**Trial 1**	**Trial 2**	**Trial 3**
Final	11.35	24.60	11.70
Initial	0.20	13.50	0.50

What is the mean titre?

A. 11.1 $cm^3 \pm 0.1\ cm^3$

B. 11.15 $cm^3 \pm 0.05\ cm^3$

C. 11.2 $cm^3 \pm 0.05\ cm^3$

D. 11.2 $cm^3 \pm 0.1\ cm^3$

39. Which spectra would show the difference between propan-2-ol, $CH_3CH(OH)CH_3$, and propanal, CH_3CH_2CHO?

I. mass
II. infrared
III. ^1H NMR

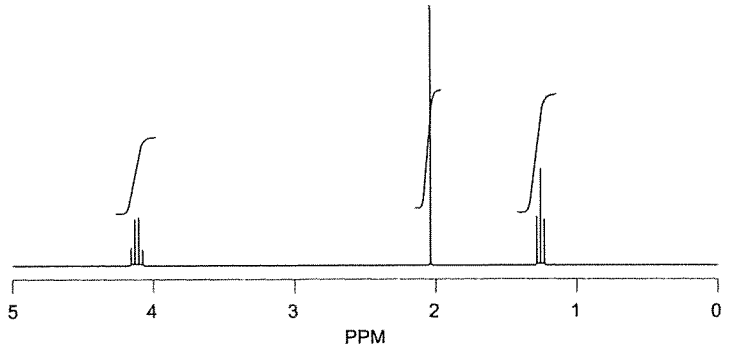
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

40. Which substance has the following ^1H NMR spectrum?



A. Propane

B. Propanal

C. Butanoic acid

D. Ethyl ethanoate

Teacher: .....

NAME: _____

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EXAMINATION CODE

8	8	2	2	-	6	1	0	2

ST JOSEPH'S INSTITUTION
Y6 PRELIMINARY EXAMINATION 2022

CHEMISTRY **12 August 2022**
HIGHER LEVEL **2 hour 15 minutes**
PAPER 2 **0945 – 1200 h**
Friday

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Write your teacher's name on the top right-hand corner of the question paper.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- Do not write anything in ink in the data booklet. All pencil marks must be erased at the end of the exam.
- The maximum mark for this examination paper is **[90 marks]**.

This question paper consists of **27** printed pages including the Cover Sheet.

Turn over

Answer **all** questions. Answers must be written within the answer boxes provided.

1. 4.406 g sample of a compound containing only C, H and O was burnt in excess oxygen. 8.802 g of CO_2 and 3.604 g of H_2O were produced.

(a) Determine the empirical formula of the compound using section 6 of the data booklet. [3]

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(b) Determine the molecular formula of this compound if its molar mass is 88.12 g mol^{-1}. If you did not obtain an answer in (a) use CS, but this is not the correct answer. [1]

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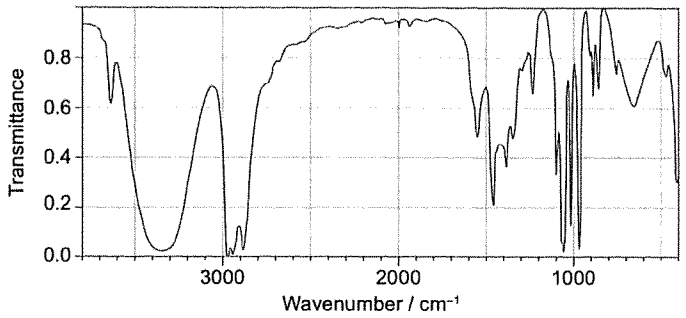
(This question continues on the following page)

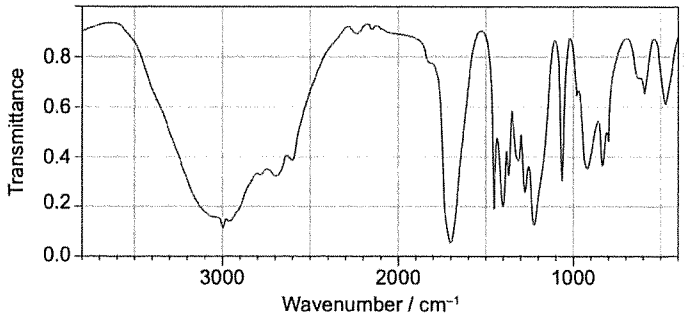
(Question 1 continued)

The following spectrums show the infrared spectra of propan-1-ol, propanal and propanoic acid.

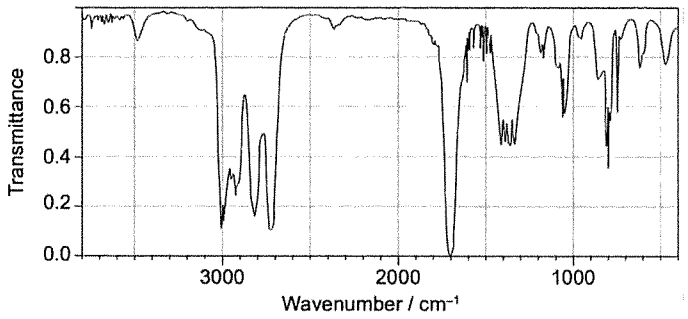
Spectrum A



Spectrum B



Spectrum C



(This question continues on the following page)

(Question 1 continued)

(c) Identify each compound from the spectra given. Use absorptions from the range of 1700 cm^{-1} to 3500 cm^{-1}. Explain the reason for your choice, referring to section 26 of the data booklet. [3]

Spectrum	Identity	Reason
A	.....	....
B	.....	....
C	.....	....

(d) Predict the number of ^1H NMR signals, and splitting pattern of the $-CH_3$ seen for propanone (CH_3COCH_3) and propanal (CH_3CH_2CHO) [2]

Spectrum	Number of signals	Splitting pattern of $-CH_3$
propanone	.....	.....
propanal	.....	.....

(This question continues on the following page)

(Question 1 continued)

(e) Predict the fragment that is responsible for a *m/z* of 31 in the mass spectrum of propan-1-ol. Use section 28 of the data booklet. [1]

.....

.....

(f) State the reagents for the conversion of propan-1-ol into propanoic acid. [1]

.....

.....

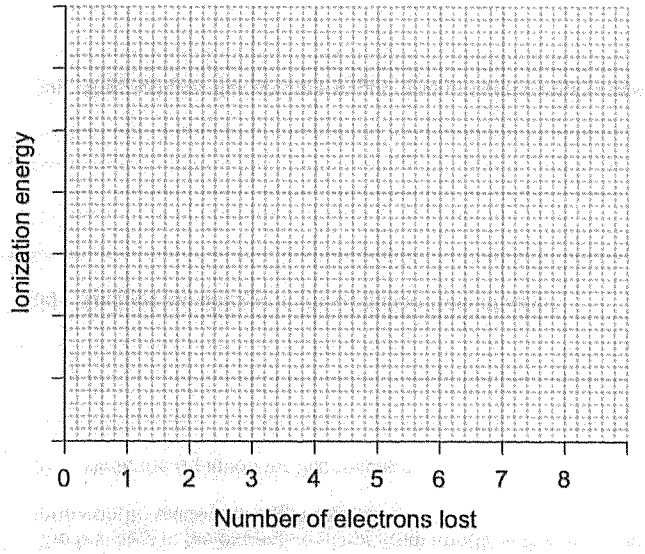
2. Iron may be extracted from iron(II) sulfide, FeS.

(a) Outline why metals, like iron, can conduct electricity. [1]

.....

.....

(b) Sketch the first eight successive ionization energies of sulfur. [2]



(c) Explain why sulfur has a smaller atomic radius than phosphorus. [2]

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(This question continues on the following page)

(Question 2 continued)

(d) Explain why the first ionization energy of sulfur is lower than that of phosphorus. [2]

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(e) Justify why sulfur is classified as a non-metal by giving two of its chemical properties. [2]

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(f) Iron(II) sulfide, FeS is an example of an ionic compound.

(i) Describe the bonding of iron(II) sulfide. [2]

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(Question 2 continued)

(This question continues on the following page)

(ii) Suggest why chemists find it convenient to classify bonding into ionic, covalent and metallic. [1]

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(g) The first step in the extraction of iron from iron(II) sulfide is to roast it in air to form iron(III) oxide and sulfur dioxide.

(i) Write the equation for this reaction. [1]

.....

(ii) Deduce the change in the oxidation state of sulfur. [1]

.....

.....

(iii) Suggest why this process might raise environmental concerns. [1]

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3. Magnetite, Fe_3O_4, is another ore of iron that contains both Fe^{2+} and Fe^{3+}.

(a) Deduce the ratio of Fe^{2+} : Fe^{3+} in Fe_3O_4. [1]

.....

.....

(b) State the condensed electronic configuration of Fe^{3+}. [1]

.....

(c) Iron exists as several isotopes.

State the number of protons, neutrons and electrons in each species. [2]

	Protons	Neutrons	Electrons
$^{54}_{26}Fe$	.....	.....	.....
$^{56}_{26}Fe^{3+}$	.....	.....	.....

(d) Transition metals like iron can form complex ions. Discuss the bonding between transition metals and their ligands in terms of acid-base theory. [2]

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(This question continues on the following page)

(Question 3 continued)

(e) Deduce, giving a reason, which complex ion $[Fe(CN)_6]^{3-}$ or $[Fe(H_2O)_6]^{3+}$ absorbs higher energy light. Use section 15 of the data booklet. [1]

.....

.....

.....

.....

(f) $Fe(H_2O)_6{}^{2+}$ forms a green solution. Estimate a wavelength of light absorbed by this complex, using section 17 of the data booklet. [1]

.....

.....

(g) Explain why, unlike typical transition metals, zinc compounds are not coloured. [2]

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4. White phosphorus is an allotrope of phosphorus and exist as P_4.

(a) Draw the Lewis (electron dot) structure of the P_4 molecule, containing only single bonds. [1]

(b) White phosphorus (P_4) can react with chlorine gas to form phosphorus trichloride.

Deduce the electron domain and molecular geometry using VSEPR theory, and estimate the Cl—P—Cl bond angle in PCl_3. [3]

Electron domain geometry: .....

Molecular geometry: .....

Bond angle: .....

(This question continues on the following page)

(Question 4 continued)

(c) An equilibrium exists between PCl_3 and PCl_5.

$$PCl_3\ (g) + Cl_2\ (g) \rightleftharpoons PCl_5\ (g)$$

(i) Calculate the standard enthalpy change ($\Delta H^{\ominus}$) for the forward reaction in kJ mol^{-1}.

$\Delta H^{\ominus}_f\ PCl_3\ (g) = -306.4$ kJ mol^{-1}

$\Delta H^{\ominus}_f\ PCl_5\ (g) = -398.9$ kJ mol^{-1} [1]

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(ii) Calculate the entropy change, ΔS, in J K^{-1} mol^{-1} for this reaction.

Substance	Entropy / J K^{-1} mol^{-1}
PCl_3 (g)	311.7
PCl_5 (g)	364.5
Cl_2 (g)	223.0

[1]

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(This question continues on the following page)

(Question 4 continued)

(iii) Calculate the Gibbs free energy change (ΔG), in kJ mol^{-1}, for this reaction at 25°C. Use section 1 of the data booklet.

If you did not obtain an answer in (c)(i) or (c)(ii), use −87.6 kJ mol^{-1} and −150.5 J mol^{-1} K^{-1} respectively, but these are not the correct answers. [2]

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(iv) Determine the equilibrium constant, K_c, for this reaction at 25°C, referring to section 1 of the data booklet.

If you did not obtain an answer in (c)(iii), use ΔG= -43.5 kJ mol^{-1}, but this is not the correct answer. [2]

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(v) State the equilibrium constant expression, K_c, for this reaction. [1]

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(This question continues on the following page)

(Question 4 continued)

(vi) State, with a reason, the effect of an increase in temperature on the position of this equilibrium. [1]

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5. The following mechanism is proposed for a reaction:

$A + B \rightarrow C + D$ slow step

$D + B \rightarrow A + E$ fast step

(a) (i) Classify substances B and D as reactant, product, catalyst, or intermediate, based on the proposed mechanism. [2]

B: .....

D: .....

(ii) Deduce the rate expression consistent with this mechanism. [1]

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(iii) Calculate the initial rate of reaction for experiment 2, if measured under the same conditions. [1]

Experiment	[A] / mol dm^{-3}	[B] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	0.200	0.200	1.20
2	0.300	0.200	

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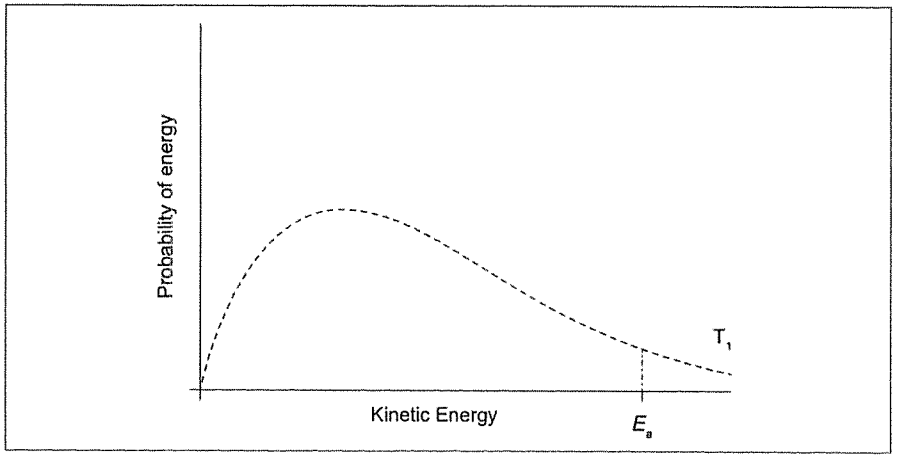
(This question continues on the following page)

(Question 5 continued)

(b) Graphing is an important tool in the study of rates of chemical reactions.

(i) The diagram shows the Maxwell-Boltzmann curve for an uncatalyzed reaction.

Draw a distribution curve at a lower temperature (T_2) and show on the diagram how the addition of a catalyst enables the reaction to take place more rapidly than at T_1 [2]



(ii) Nitrogen dioxide and carbon monoxide react according to the following equation:

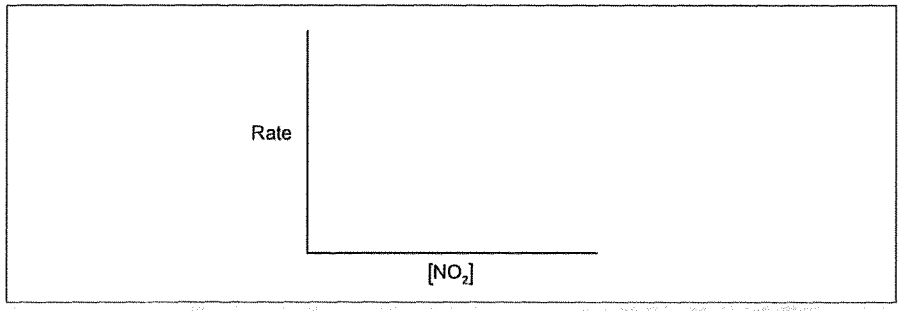
$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$ $\Delta H = -226$ kJ

Experimental data shows the reaction is second order with respect to NO_2 and zero order with respect to CO.

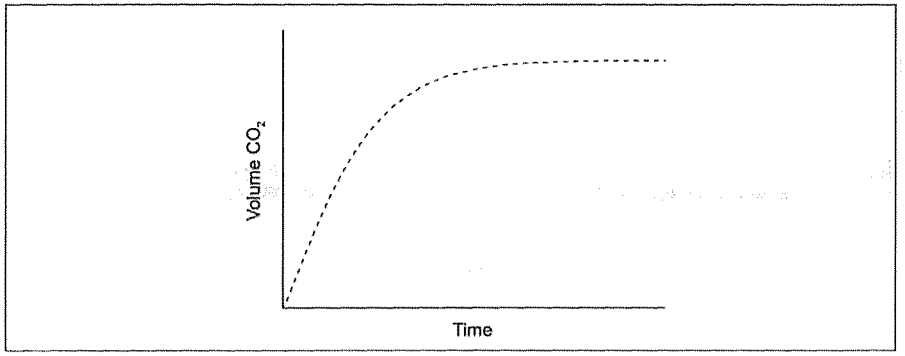
Sketch the relationship between the rate of reaction and the concentration of NO_2. [1]

(This question continues on the following page)

(Question 5 continued)



(iii) Excess hydrochloric acid is added to lumps of calcium carbonate. The graph shows the volume of carbon dioxide gas produced overtime.



Sketch a curve on the graph to show the volume of gas produced over time if the same mass of crushed calcium carbonate is used instead of lumps. All other conditions remain constant.

[1]

6. A mixture of 1.00 mol SO_2 (g), 2.00 mol O_2 (g) and 1.00 mol SO_3 (g) is placed in a 1.00 dm^3 container and allowed to reach equilibrium.

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)$$

(a) Distinguish between the term reaction quotient, Q and equilibrium constant, K_c. [1]

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(b) The equilibrium constant, K_c is 0.292 at temperature T.

Deduce, showing your work, the direction of the initial reaction. [2]

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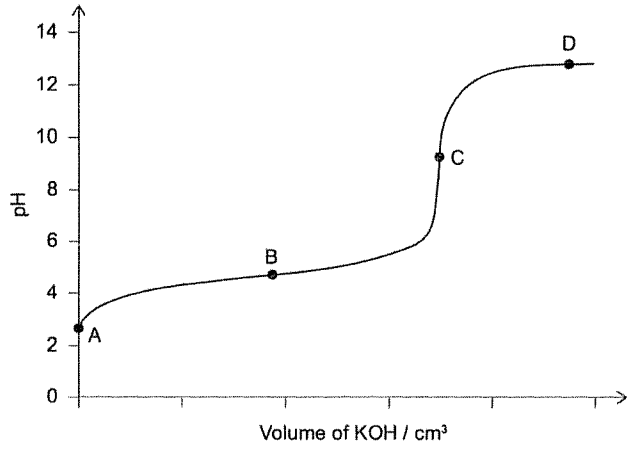
7. A student performs a titration to determine the concentration of ethanoic acid, CH_3COOH, in vinegar using potassium hydroxide.

(a) The pH curve for the reaction is given.



(i) Identify the major species, other than water and potassium ion, at these points. [2]

B : .....

C : .....

(ii) State a suitable indicator for this titration. Use section 22 of the data booklet. [1]

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(This question continues on the following page)

(Question 7 continued)

(iii) Suggest, giving a reason which point of the curve is considered a buffer region. [1]

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(iv) Explain using appropriate equations, how a suitable mixture of ethanoic acid with potassium hydroxide acts as a buffer solution. [2]

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(b) Calculate the K_b of the conjugate base of ethanoic acid using sections 2 and 21 of the data booklet. [1]

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(Question 7 continued)

(c) Calculate the pH of 0.0100 mol dm^{-3} ethanoic acid stating any assumption you make. Use section 21 of the data booklet. [3]

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Assumption:

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(d) In a titration, 25.00 cm^3 of vinegar required 20.75 cm^3 of 1.00 mol dm^{-3} potassium hydroxide to reach the end-point.

Calculate the concentration of ethanoic acid in the vinegar. [2]

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(This question continues on the following page)

(Question 7 continued)

(e) Potassium hydroxide solution can react with carbon dioxide from the air. The solution was made one day prior to using it in the titration.

(i) State the type of error that would result from the student's approach. [1]

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(ii) Predict, giving a reason, the effect of this error on the calculated concentration of ethanoic acid in 7(d). [2]

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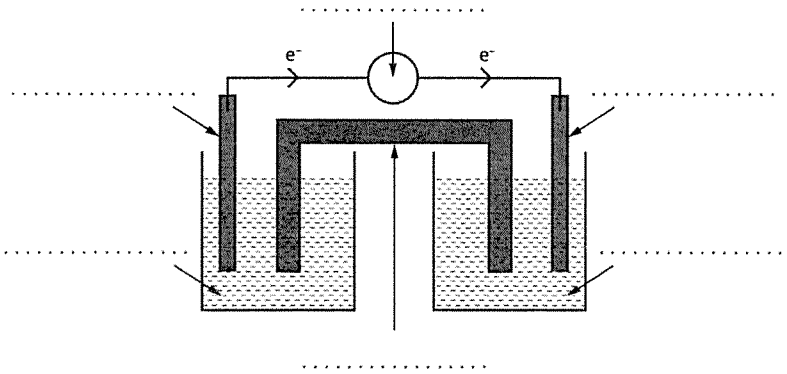
8. Oxidation and reduction can have a variety of commercial uses.

(a) A student decides to build a voltaic cell of an aluminium electrode, Al (s), a tin electrode, Sn (s) and solutions of aluminium nitrate, $Al(NO_3)_3$ (aq) and tin(II) nitrate, $Sn(NO_3)_2$ (aq)

Electron flow is represented on the diagram.

Label each line in the diagram using section 25 of the data booklet. [3]



(b) Write the equation for the expected overall chemical reaction in (a). [1]

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(This question continues on the following page)

(Question 8 continued)

(c) Calculate the cell potential using section 24 of the data booklet. [1]

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(d) Calculate the Gibbs free energy change, $\Delta G^{\ominus}$ in kJ, for the cell, using section 1 of the data booklet. [2]

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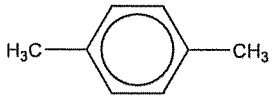
9. Xylene is a derivative of benzene. One isomer is 1,4-dimethylbenzene.



(a) Outline one piece of physical evidence for the structure of benzene ring. [1]

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(b) Draw the structure of one other isomer of xylene which retains the benzene ring. [1]

(c) Xylene, like benzene, can be nitrated.

(i) Write the equation for the production of the active nitrating agent from concentrated sulfuric and nitric acid. [1]

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(This question continues on the following page)

(Question 9 continued)

(ii) Explain the mechanism for the nitration of benzene, using curly arrows to indicate the movement of electron pairs. [4]

(This question continues on the following page)

(Question 9 continued)

(d) Nitrobenzene, $C_6H_5NO_2$ can be converted to phenylamine via a two-stage reaction. In the first stage, nitrobenzene is reduced with tin in an acidic solution to form an intermediate ion and tin(II) ions. In the second stage, the intermediate ion is converted to phenylamine in the presence of hydroxide ions.

Formulate the equation for each stage of the reaction. [2]

Stage one:

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Stage two:

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