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A Level Further Mathematics B (MEI)
Y432 Statistics Minor
Sample Question Paper Version 2

Date – Morning/Afternoon
Time allowed: 1 hour 15 minutes

You must have:
- Printed Answer Booklet
- Formulae Further Mathematics B (MEI)

You may use:
- a scientific or graphical calculator

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes provided on the Printed Answer Booklet with your name, centre number and candidate number.
- Answer **all** the questions.
- **Write your answer to each question in the space provided in the Printed Answer Booklet.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

INFORMATION
- The total number of marks for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is used. You should communicate your method with correct reasoning.
- The Printed Answer Booklet consists of **12** pages. The Question Paper consists of **8** pages.

Answer **all** the questions.

1 A darts player is trying to hit the bullseye on a dart board. On each throw the probability that she hits it is 0.05, independently of any other throw.

(i) Find the probability that she hits the bullseye for the first time on her 10th throw. **[2]**

(ii) Find the probability that she does not hit the bullseye in her first 10 throws. **[1]**

(iii) Write down the expected number of throws which it takes her to hit the bullseye for the first time. **[1]**

2 The number of televisions of a particular model sold per week at a retail store can be modelled by a random variable X with the probability function shown in the table.

x	0	1	2	3	4
$\mathrm{P}(X=x)$	0.05	0.2	0.5	0.2	0.05

(i) (*A*) Explain why $\mathrm{E}(X)=2$. **[1]**

(*B*) Find $\mathrm{Var}(X)$. **[3]**

(ii) The profit, measured in pounds made in a week, on the sales of this model of television is given by Y, where $Y=250X-80$.
Find

- $\mathrm{E}(Y)$ and
- $\mathrm{Var}(Y)$. **[2]**

The remote controls for the televisions are quality tested by the manufacturer to see how long they last before they fail.

(iii) Explain why it would be inappropriate to test all the remote controls in this way. **[1]**

(iv) State an advantage of using random sampling in this context. **[1]**

3 A website awards a random number of loyalty points each time a shopper buys from it. The shopper gets a whole number of points between 0 and 10 (inclusive). Each possibility is equally likely, each time the shopper buys from the website. Awards of points are independent of each other.

(i) Let X be the number of points gained after shopping once.
Find
- the mean of X
- the variance of X. **[3]**

(ii) Let Y be the number of points gained after shopping twice.
Find
- the mean of Y
- the variance of Y. **[3]**

(iii) Find the probability of the most likely number of points gained after shopping twice. Justify your answer. **[4]**

4 **(i)** State the conditions under which the Poisson distribution is an appropriate model for the number of emails received by one person in a day. **[2]**

Jane records the number of junk emails which she receives each day. During working hours (9am to 5pm, Monday to Friday) the mean number of junk emails is 7.4 **per day**. Outside working hours (5pm to 9am), the mean number of junk emails is 0.3 **per hour**.

For the remainder of this question, you should assume that Poisson models are appropriate for the number of junk emails received during each of "working hours" and "outside working hours".

(ii) Find the probability that the number of junk emails which she receives between 9am and 5pm on a Monday is

(A) exactly 10, **[1]**

(B) at least 10. **[2]**

(iii) (A) What assumption must you make to calculate the probability that the number of junk emails which she receives from 9am Monday to 9am Tuesday is at most 20? **[1]**

(B) Find the probability. **[2]**

5 Each contestant in a talent competition is given a score out of 20 by a judge. The organisers suspect that the judge's scores are associated with the age of the contestant. Table 5.1 and the scatter diagram in Fig. 5.2 show the scores and ages of a random sample of 7 contestants.

Contestant	A	B	C	D	E	F	G
Age	66	51	39	29	9	22	14
Score	12	11	15	17	16	18	9

Table 5.1

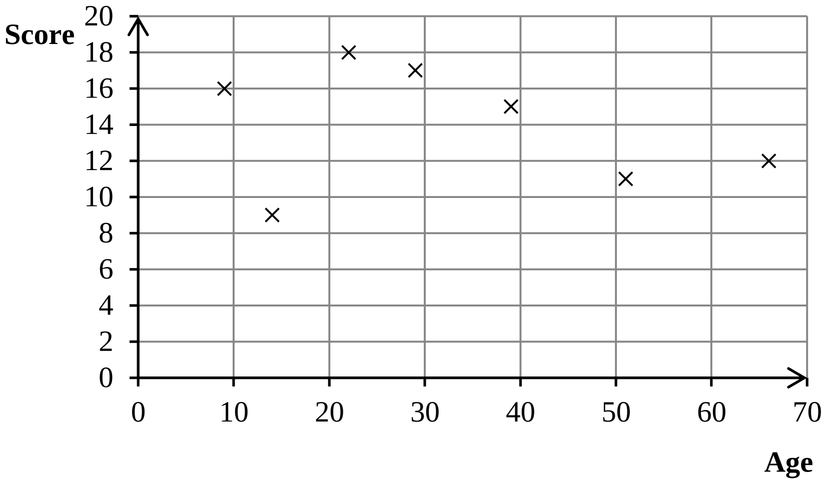

Fig. 5.2

Contestant G did not finish her performance, so it is decided to remove her data.

(i) Spearman's rank correlation coefficient between age and score, including all 7 contestants, is −0.25. Explain why Spearman's rank correlation coefficient becomes more negative when the data for contestant G is removed. **[1]**

(ii) Calculate Spearman's rank correlation coefficient for the 6 remaining contestants. **[3]**

(iii) Using this value of Spearman's rank correlation coefficient, carry out a hypothesis test at the 5% level to investigate whether there is any association between age and score. **[5]**

(iv) Briefly explain why it may be inappropriate to carry out a hypothesis test based on Pearson's product moment correlation coefficient using these data. **[1]**

6 At a bird feeding station, birds are captured and ringed. If a bird is recaptured, the ring enables it to be identified. The table below shows the number of recaptures, x, during a period of a month, for each bird of a particular species in a random sample of 40 birds.

Number of recaptures, x	0	1	2	3	4	5	6	7	8	9	10
Frequency	2	5	5	9	10	4	3	1	0	1	0

(i) The sample mean of x is 3.4. Calculate the sample variance of x. **[2]**

(ii) Briefly comment on whether the results of part **(i)** support a suggestion that a Poisson model might be a good fit to the data. **[1]**

The screenshot below shows part of a spreadsheet for a χ^2 test to assess the goodness of fit of a Poisson model. The sample mean of 3.4 has been used as an estimate of the Poisson parameter. Some values in the spreadsheet have been deliberately omitted.

	A	B	C	D	E
1	Number of recaptures	Observed frequency	Poisson probability	Expected frequency	Chi-squared contribution
2	0 or 1	7	0.1468	5.8737	0.2160
3	2	5			0.9560
4	3	9	0.2186	8.7447	0.0075
5	4	10	0.1858	7.4330	0.8865
6	5	4	0.1264	5.0544	
7	≥6	5	0.1295	5.1783	0.0061

(iii) State the null and alternative hypotheses for the test. **[1]**

(iv) Calculate the missing values in cells
- C3,
- D3 and
- E6. **[4]**

(v) Complete the test at the 10% significance level. **[5]**

(vi) The screenshot below shows part of a spreadsheet for a χ^2 test for a different species of bird. Find the value of the Poisson parameter used.

	A	B	C	D	E
1	Number of recaptures	Observed frequency	Poisson probability	Expected frequency	Chi-squared contribution
3	1	10	0.25716	12.8579	0.6352
4	2	7	0.27002	13.5008	3.1302
5	3	15	0.18901	9.4506	3.2587
6	≥4	11	0.16136	8.0679	1.0656

[3]

7 A fair coin has +1 written on the heads side and -1 on the tails side. The coin is tossed 100 times. The sum of the numbers showing on the 100 tosses is the random variable Y. Show that the variance of Y is 100. **[4]**

END OF QUESTION PAPER

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…day June 20XX – Morning/Afternoon

A Level Further Mathematics B (MEI)

Y432 Statistics Minor

SAMPLE MARK SCHEME

Duration: 1 hour 15 minutes

MAXIMUM MARK 60

This document consists of 12 pages

Text Instructions

1. Annotations and abbreviations

Annotation in scoris	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining a result or establishing a given result
dep*	Mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This indicates that the instruction **In this question you must show detailed reasoning** appears in the question.

2. Subject-specific Marking Instructions for A Level Further Mathematics A

a Annotations should be used whenever appropriate during your marking. The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded. For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
If you are in any doubt whatsoever you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep*' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.) We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so. When a value is given in the paper only accept an answer correct to at least as many significant figures as the given value. This rule should be applied to each case. When a value is not given in the paper accept any answer that agrees with the correct value to 2 s.f. Follow through should be used so that only one mark is lost for each distinct accuracy error, except for errors due to premature approximation which should be penalised only once in the examination. There is no penalty for using a wrong value for *g*. E marks will be lost except when results agree to the accuracy required in the question.

g Rules for replaced work: if a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests; if there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others. NB Follow these maths-specific instructions rather than those in the assessor handbook.

h For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some papers. This is achieved by withholding one A mark in the question. Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working. 'Fresh starts' will not affect an earlier decision about a misread. Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j If in any case the scheme operates with considerable unfairness consult your Team Leader.

k Anything in the mark scheme which is in square brackets […] is not required for the mark to be earned on this occasion, but shows what a complete solution might look like

Question			Answer	Marks	AOs	Guidance	
1	**(i)**		$0.95^9 \times 0.05$ $= 0.0315$	**M1** **A1** **[2]**	**3.3** **1.1**		
1	**(ii)**		$0.95^{10} = 0.599$	**B1** **[1]**	**1.1**		
1	**(iii)**		$\frac{1}{0.05} = 20$	**B1** **[1]**	**1.1**		
2	**(i)**	(*A*)	The distribution is symmetrical so E(X) is at the centre i.e. 2	**B1** **[1]**	**2.4**	Or use of $0\times0.05+1\times0.2+2\times0.5...$ $+3\times0.2+4\times0.05$	
2	**(i)**	(*B*)	$E(X^2) = (0^2 \times 0.05) + (1^2 \times 0.2) + (2^2 \times 0.5) + (3^2 \times 0.2) + (4^2 \times 0.05)$ $= 4.8$ $\text{Var}(X) = 4.8 - 2^2$ $= 0.8$	**M1** **M1** **A1FT** **[3]**	**1.1** **1.2** **1.1**	For $\Sigma r^2 p$ (at least 3 terms correct) dep for – their $E(X)^2$ FT their E(X) provided Var(X) > 0	
2	**(ii)**		$E(Y) = 250 \times 2 - 80 = 420$ $\text{Var}(Y) = 250^2 \times 0.8 = 50\,000$	**B1FT** **B1FT** **[2]**	**1.1** **1.1**	FT their E(X) FT their Var(X)	
2	**(iii)**		Testing all of them not suitable as they will not be available to sell to customers.	**E1** **[1]**	**2.4**	OR It would take too long	
2	**(iv)**		Random sample avoids unsuspected sources of bias.	**E1** **[1]**	**1.2**	OR allows inference	

Question			Answer	Marks	AOs	Guidance	
3	(i)		E(X) = 5 $\text{Var}(X) = \frac{10\times12}{12}$ $=10$	**B1** **M1** **A1** **[3]**	**1.1** **3.3** **1.1**		
3	(ii)		For 2 visits mean = 10 Variance = 10 + 10 = 20	**B1FT** **M1** **A1** **[3]**	**1.1** **3.4** **1.1**	FT *their* **(i)**	
3	(iii)		[Working leading to] 121 possibilities Most likely total is 10. E.g. This is the one on the main diagonal of the sample space so occurs most often. Probability = $\frac{11}{121}$ oe	**M1** **A1** **E1** **B1FT** **[4]**	**3.1b** **1.1** **2.4** **3.2a**	E.g. starting list (0, 10), (0, 9) or as sample space or calculation 11 × 11. Implied by probability out of 121 Justification FT correct probability for *their* most likely total	

Question			Answer	Marks	AOs	Guidance	
4	**(i)**		Receipt of an email is an event which occurs randomly, independently and at a uniform average rate.	**E1** **E1** **[2]**	**3.3** **3.3**	 Allow constant average rate	
4	**(ii)**	(*A*)	Poisson mean 7.4 P(X = 10) = 0.0829	**B1** **[1]**	**1.1**	BC	
4	**(ii)**	(*B*)	P($X \geq 10$) = 1 – 0.7877 = 0.2123.	**M1** **A1** **[2]**	**3.4** **1.1**	OR P($X \geq 10$) = 1 – P($X \leq 9$) BC	
4	**(iii)**	(*A*)	Numbers of junk emails arriving during working hours and outside working hours are independent.	**E1** **[1]**	**3.5b**	E.g. sum of independent Poisson distributions is Poisson	
4	**(iii)**	(*B*)	Mean = 7.4 + 16×0.3 = 12.2 P($X \leq 20$) = 0.9863	**B1** **B1** **[2]**	**3.3** **1.1**	 BC	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AOs</th><th colspan="2">Guidance</th></tr>
<tr><td>5</td><td>(i)</td><td></td><td>Spearman’s correlation coefficient will become more negative as there is a stronger tendency for score to go down as age goes up.</td><td>E1

[1]</td><td>2.4</td><td>oe</td><td>Saying it is closer to a straight line does not get the mark.</td></tr>
<tr><td>5</td><td>(ii)</td><td></td><td><table><tr><td>Contestant</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td></tr><tr><td>Age rank</td><td>6</td><td>5</td><td>4</td><td>3</td><td>1</td><td>2</td></tr><tr><td>Score rank</td><td>2</td><td>1</td><td>3</td><td>5</td><td>4</td><td>6</td></tr></table>$r_S = –0.7714$ (4 s.f.)</td><td>M1

M1

A1
[3]</td><td>1.1

1.1

1.1</td><td>For ranking Age

For ranking Score

BC</td><td>can be reversed as long as consistent
can be reversed as long as consistent</td></tr>
<tr><td>5</td><td>(iii)</td><td></td><td>H_0: there is no association between age and score.
H_1: there is an association between age and score.

For $n = 6$ 5% critical value is 0.8857

Since 0.7714< 0.8857

Do not reject the null hypothesis
There is insufficient evidence to suggest at the 5% level that there is association between age and score.</td><td>B1
B1

B1

M1

A1FT

[5]</td><td>3.3
2.5

3.4

1.1

2.2b</td><td>B1 for H_0
B1 for H_1 and population soi
NB H_0 H_1 <u>not</u> in terms of ρ

B1 for $\pm$ 0.8857

M1 for comparison with critical value, provided $|r_s| < 1$

A1 for conclusion in words FT their r_s and sensible critical value</td><td>hypotheses as shown in the answer column should be understood to imply population</td></tr>
<tr><td>5</td><td>(iv)</td><td></td><td>Cannot tell if it is bivariate Normal</td><td>E1
[1]</td><td>3.5b</td><td>E.g. score must be an integer</td><td></td></tr>
</table>

Question			Answer	Marks	AOs	Guidance	
6	(i)		Standard deviation = 1.90546... Sample variance = 3.63	**M1** **A1** **[2]**	**1.1** **1.1**	BC	**SC1** for square of other "standard deviation" to get 3.54
6	(ii)		Mean not too far from variance so Poisson may be suitable	**E1** **[1]**	**2.2b**	Not "Poisson is good fit" (must be non-assertive).	
6	(iii)		H_0: Poisson model is a good fit H_1: Poisson model is not a good fit	**B1** **[1]**	**2.5**	Ignore any reference to the value of the Poisson parameter	
6	(iv)		Cell C3 = 0.1929 Cell D3 = 7.7159 Cell E6 $= \frac{(4-5.0544)^2}{5.0544}$ $=0.2200$	**B1** **B1FT** **M1** **A1** **[4]**	**3.4** **2.2a** **1.1a** **1.1**	40 times *their* C3	
6	(v)		$X^2 = 2.292$ Refer to X_4^2 Critical value at 10% level = 7.779 2.292 < 7.779 Do not reject H_0 There is insufficient evidence to suggest that the Poisson model is not a good fit.	**B1** **M1** **A1** **M1** **A1** **[5]**	**1.1** **3.4** **1.1** **1.1** **2.2b**	 Degrees of freedom = 4 soi Comparison with critical value Conclusion	 last two marks allowed if 5 degrees of freedom used

Question			Answer	Marks	AOs	Guidance	
6	(vi)		$\frac{e^{-\lambda}\lambda}{1} = 0.25716$ and $\frac{e^{-\lambda}\lambda^2}{2} = 0.27002$	M1	3.1b	OR $\frac{e^{-\lambda}\lambda^2}{2} = 0.27002$ and $\frac{e^{-\lambda}\lambda^3}{3!} = 0.18901$	
			$\frac{\lambda}{2} = \frac{0.27002}{0.25716}$	M1	2.2a	OR $\frac{\lambda}{3} = \frac{0.18901}{0.27002}$	
			$\lambda = 2.1$	A1	1.1		
				[3]			
7			Let X be the number of heads on the 100 tosses [X ~ Bin (100, 0.5)]	M1	3.3		
			$Y = X - (100 - X) = 2X - 100$	M1	3.1b		
			Var (Y) = 4 Var (X)	M1	1.1		
			Var (X) = npq so $\text{Var}(Y) = 4\times100\times0.5\times0.5$ = 100 AG	E1	2.1		
				[4]			

Question	AO1	AO2	AO3(PS)	AO3(M)	Totals
1i	1	0	0	1	2
1ii	1	0	0	0	1
1iii	1	0	0	0	1
2iA	0	1	0	0	1
2iB	3	0	0	0	3
2ii	2	0	0	0	2
2iii	0	1	0	0	1
2iv	1	0	0	0	1
3i	2	0	0	1	3
3ii	2	0	0	1	3
3iii	1	1	2	0	4
4i	0	0	0	2	2
4iiA	1	0	0	0	1
4iiB	1	0	0	1	2
4iiiA	0	0	0	1	1
4iiiB	1	0	0	1	2
5i	0	1	0	0	1
5ii	3	0	0	0	3
5iii	1	2	0	2	5
5iv	0	0	0	1	1
6i	2	0	0	0	2
6ii	0	1	0	0	1
6iii	0	1	0	0	1
6iv	2	1	0	1	4
6v	3	1	0	1	5
6vi	1	1	1	0	3
7	1	1	1	1	4
Totals	30	12	4	14	60

Summary of Updates

Date	Version	Change
October 2019	2	Amendments to the front cover rubric instructions to candidates

Oxford Cambridge and RSA

Accredited

A Level Further Mathematics B (MEI)

Y432 Statistics Minor

Printed Answer Booklet Version 2

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Last name	

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QN: 603/1364/X

1 (i)	
1 (ii)	
1 (iii)	
2 (i) (*A*)	
2 (i) (*B*)	

2 (ii)	
2 (iii)	
2 (iii)	
2 (iv)	

3 (i)	
3 (ii)	
3 (iii)	

4 (i)	
4 (ii) (*A*)	
4 (ii) (*B*)	
4 (iii) (*A*)	
4 (iii) (*B*)	

5 (i)	
5 (ii)	
5 (iii)	**(answer space continued on next page)**

5 (iii)	**(continued)**
5 (iv)	
6 (i)	

6 (ii)	
6 (iii)	
6 (iv)	

6 (v)	

6 (vi)	
7	
	(answer space continued on next page)

(answer space continued on next page)

7	**(continued)**

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