| **Question** | **Scheme** | **Marks** |
| --- | --- | --- |
| **1(a)** | Po(9) | B1 |
| **(i)** |  = 0.3239 – 0.2068   | M1 |
|  = 0.1171 | A1 |
| **(ii)** |  | M1 |
|  = 1 – 0.5874 |  |
|  = 0.4126 | A1 |
|  | **(5)** |
| **1(b)** | Po(1.5) | B1 |
| P(next patient before 11:45) = 1- P(0)  | M1 |
|  = 1 - e-1.5  |  |
|  = 0.7769 | A1 |
|  |  | **(3)** |
|  |  | **(8 marks)** |
| **2(a)** | *n* large | B1 |
| *p* small | B1 |
|  |  |  **(2)** |
| **2(b)** | Let *X* be the random variable the number of letters delivered to the wrong house |  |
| *X*~B(1000,0.01)  |  |
| Po(10)  | B1 |
| P(*X* > 4) = 1 – P(*X* < 3)  | M1 |
|  = 1 – 0.0103 |  |
|  = 0.9897 | A1 |
|  |  |  **(3)** |
|  |  | **(5 marks)** |
| **3(a)** | Occurrences of the disease are independent  | B1 |
| The probability of catching the disease remains constant  | B1 |
|  |  | **(2)** |
| **3(b)** | *X* ~ Bin (10, 0.03) | B1 |
| P(*X* = 2) = =0.0317 | M1A1 |
|  |  | **(3)** |
| **3(c)** | E(*X*) = 100 × 0.03 = 3 | B1cao |
| Var (*X*) = 100 × 0.03 × 0.97 = 2.91 | B1cao |
|  |  | **(2)** |
| **3(d)** | *λ* = 100 × 0.03 = 3 |  |
| *Y* ~ Po(3) | B1 (use of) |
| P(*Y* > 5) = 1 – P(*Y* ≤ 5) | dM1 |
|  = 1 – 0.9161 |  |
|  = 0.0839 | A1 |
|  |  | **(3)** |
|  |  | **(10 marks)** |
| **4(a)** | Mean = 1.41 | B1 cao allow 141/100 | B1 |
| Variance =  | M1: using  or  oeNB Allow the square root of this for the M mark. If no working shown for then you must see 343, 3.43 or correct answer | M1 |
| = 1.4419 (*s*2 = 1.456) | A1: awrt 1.44 or 1.46 for *s*2 | A1 |
|  |  |  **(3)** |
| **4(b)** | The mean is close to the variance | B1: cao – allow alternative wording Allow mean equals variance | B1 |
|  |  |  **(1)** |
| **4(c)(i)** | *X* ~ Po(1.5)P(*X* = 2) =  | M1: writing or using  or P(*X* ≤ 2) – P(*X* ≤ 1) | M1 |
|  | = 0.2510 | A1: awrt 0.251 | A1 |
| **4(c)(ii)** | P(*X* ≥ 2) = 1 – P(*X* = 0)= 1 – e– 1.5 or 1 – 0.2231 | M1: writing or using 1 – P(*X* = 0) oe | M1 |
| = 0.77686… | A1: awrt 0.777 | A1 |
|  |  |  **(4)** |
| **4(d)** | *Y* ~ Po(7.5) | B1: writing Po(7.5) | B1 |
| P(*Y* ≥ 11) = 1 – P(*Y* ≤ 10) | M1: writing P(*Y* ≥ 11) or 1 – P(*Y* ≤ 10) oe | M1 |
| = 1 – 0.8622= 0.1378 \* | A1: seeing 1 – 0.8622 leading to 0.1378 cso (both B1 and M1 awarded) | A1cso |
|  |  |  **(3)** |
| **4(e)** | *A* ~ B(12, 0.1378) | M1: using  where *p* = 0.1378 or 0.138Condone missing *n*C*r* | M1 |
| P(*A* = 3) =  | M1:  with 0 < *p* < 1Allow 220 or 12 C 3 instead of  | M1 |
| = 0.1516 | A1: awrt 0.152 | A1 |
|  |  |  **(3)** |
|  |  | **(14 marks)** |
| **5(a)(i)** | $X\~$Po(2.5) |  |
| P(*X* 4) =   = 1 – 0.7576 | M1 |
|  = 0.2424  | A1 |
| **5(a)(ii)** | $X\~$Po(0.625) | B1 |
| P(*X =* 3) =  | M1 |
|  = 0.02177...  | A1 |
|  |  | **(5)** |
| **5(b)** | 1 - P(*X* = 0) < 0.2 P(*X* = 0) > 0.8 | M1 |
|   *t* < 0.089… hours = 5.36 mins | M1 |
|  [ *t* <] 5 mins | A1cso |
|  |  | **(3)** |
| **5(c)** | H0: $ p=0.25$H1: $ p<0.25$ | B1 |
|  = 1 – 0.9682  | M1 |
|  = 0.0318  | A1 |
|  |  |
| Sufficient evidence to reject H0, Accept H1, significant. 10 does lie in the Critical region. | M1d |
| There is sufficient evidence that the mean rate of telephone **calls** has increased **(oe)** | A1cso |
|  |  | **(5)** |
|  |  | **(13 marks)** |
| **6(a)(i)** | P(*X* < 5) = 0.8424 awrt 0.842 | B1 |
| **6(a)(ii)** | P(*X* *>* 7) = 1 – P(*X*  6) | M1 |
|  = 1 – 0.9857 |  |
|  = 0.0143 awrt 0.0143 | A1 |
|  |  | **(3)** |
| **6(b)** | P(*X* = 0) = (1 – *p*)12 |  |
| (1 – *p*)12 = 0.05  | M1 |
|  (1 – *p*) =  | M1 |
|  *p* = 0.221 awrt 0.221 | A1 |
|  |  | **(3)** |
| **6(c)** | Variance =12*p*(1– *p*)  |   |
| 12*p*(1– *p*) = 1.92 | M1 |
| 12*p* – 12*p*2 = 1.92 |  |
| 12*p*2 – 12*p* + 1.92 = 0 or *p*2 – *p* + 0.16 = 0  25*p*2 – 25*p* + 4 = 0 |  |
| *p*  =  (5*p* – 1)(5*p* – 4) = 0 | M1 |
| *p* = 0.2 or 0.8 | A1A1 |
|  |  | **(4)** |
|  |  | **(10 marks)** |
| **7(a)** | *X* ~ B(120,0.075) | B1 |
| Approximated by Po(9) | M1A1 |
|  | M1 |
|  |  |
|  awrt 0.979 | A1 |
|  |  | **(5)** |
| **7(b)** | P(At least 4 defective components in each box) | M1 |
|  |  |
|  awrt 0.958 | A1 |
|  |  | **(2)** |
|  |  | **(7 marks)** |
| **8(a)** | *X* ~ B(20, 0.2) | M1A1 |
|  |  | **(2)** |
| **8(b)** | *S* = 4*X* – 1(20 – *X*)  | M1 |
|  *S* = 5*X* – 20  | A1cso |
|  |  | **(2)** |
| **8(c)** | E(*X*) = 4, Var(*X*) = 3.2 | B1B1 |
|  | E(*S*) = , Var(*S*) = Var(*X*) = 80 | MA1 |
|  |  | **(4)** |
| **8(d)** | *S* > 20 implies 5*X* – 20 > 20 | M1 |
| [So 5*X* > 40 ] *X* > 8  | A1 |
| P(*S* > 20) = P(*X* > 8) = 1 – P(*X* < 7) | M1 |
|  = 1 – 0.9679 = **0.0321** | A1 |
|  |  | **(4)** |
| **8(e)** | [Let *C* = no. Cameron gets correct. *C* ~ B(100, 0.4) ] *Y* ~ N(40, )  | M1A1 |
| P(*C* > 50) ~ P(*Y* > 50.5) |  |
|  =  | M1M1 |
|  = P(*Z* > 2.14...) = 1 – 0.9838 = 0.0162 or 0.016044.. (awrt **0.016**) | A1 |
| N.B. exact Bin (0.01676...) Poisson approx (0.0526...) |  |
|  |  | **(5)** |
|  |  | **(17 marks)** |
| **9(a)** | Distribution B(*n,*0.1) | B1 |
|  |  | **(1)** |
| **9(b)** | *Y* ~ B (10, 0.1) | B1 |
| P(*Y* ≥ 4) = 1 – P(*Y* ≤ 3) | M1 |
|  = 1 – 0.9872 |  |
|  = 0.0128 | A1 |
|  |  | **(3)** |
| **9(c)** |  |  |
| (0.9) < 0.05 or 1 – (0.9)*n*> 0.95 | M1 |
|  *n* > 28.4 | A1 |
|  *n* = 29 | A1 |
| *alternative* |  |
| B(28,0.1): P(0) = 0.0523 | M1 |
| B(29,0.1): P(0) = 0.0471 | A1 |
| *n* = 29 | A1cao |
|  |  | **(3)** |
| **9(d)** | *C* ~ Po(5) | B1 |
| P(*C* >10) =1 – P(*C* ≤ 10) | M1 |
|  = 1 – 0.9863 |  |
|  = 0.0137 | A1 |
|  |  | **(3)** |
|  |  | **(10 marks)** |

|  |  |  |  |  |  |
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|  | **Source paper** | **Question number** | **New spec references** | **Question description** | **New AOs** |
| 1 | S2 2014 | 1 | FS1 2.1 | Binomial and Poisson distributions | 1.1b, 3.3, 3.4 |
| 2 | S2 Jan 2013 | 1 | FS1 2.3 | Poisson and binomial distributions | 1.1b, 1.2, 3.4 |
| 3 | S2 Jan 2011 | 1 | FS1 2.1, 2.2, 2.3 | Poisson and binomial distributions | 1.1b, 1.2, 3.3, 3.4 |
| 4 | S2 2016 | 1 | FS1 2.1 | Poisson and binomial distributions | 1.1b, 2.1, 2.4, 3.3, 3.4 |
| 5 | S2 2017 | 2 | FS1 2.1, 2.4 | Poisson and binomial distributions | 1.1b, 2.2b, 2.4, 2.5, 3.1b |
| 6 | S2 Jan 2013 | 3 | FS1 2.2 | Poisson and binomial distributions | 1.1b, 2.1, 3.4 |
| 7 | S2 Jan 2012 | 5 | FS1 2.1, 2.2, 2.3 | Poisson and binomial distributions | 1.1b, 3.1b, 3.3, 3.4 |
| 8 | S2 2013R | 7 | FS1 1.1, 2.2 | Binomial hypothesis test  | 1.1b, 2.1, 3.1b, 3.3, 3.4 |
| 9 | S2 2013 | 7 | FS1 2.2, 2.3 | Poisson and binomial distributions | 1.1b, 3.1b, 3.3, 3.4 |