**1a.** (N) Sample Size - 1 mark

(p) Probability of Success - 1 mark

**1b.** p varies with dose,

linear on link scale (correct link used - logit here),

independence of Y,

binomial distribution is the correct distribution for our error,

dispersion parameter is constant (and correct one chosen),

no outliers

 (6 marks, 1 per answer)

**1c.** Cloglog or probit (accepted with and without capitals)

**2a.** Yes. The z-test for Concentration, the deviance test, and the confidence interval all suggest it's horribly significant (a strong and clearly estimated effect).

6 marks: one for saying yes, one for "it's significant"/remains when we include uncertainty (by whatever measure), and 4 for giving statistics i.e. a confidence interval, a standard error, an estimate, direction etc.

E.g. Yes the analysis does support the assumption of an effect of log(concentration) on the proportion of beetles killed. The estimated effect is positive (an increase of 33.784 in log odds for every 1 increase in log(concentration)). The standard error of the effect is 2.870 this is much lower than 2 times the estimate, so the confidence intervals of this effect will be small (approx. width of 12 log odds per log(concentration)). This suggests that even with uncertainty included, this is still a strong positive effect. This is further confirmed by the p-value of <2e-16, which shows the effect is statistically significant because there is a low probability of seeing our estimated statistic or higher if the null hypothesis of no effect was true.

**2b.** some variations on this are allowed. **If you think you entered something correct, but it was graded wrong, please contact us!**

**3a.** 1.77

**4a.** 1.75 to 1.77 (range of acceptable answer)

**4b.** 1.77 to 1.79 (range of acceptable answer)

**5a.** Evidence of curvature (2 point)

Could transform log(Concentration), or use a quadratic (could use a different link function) (1 point each)

**6a.** 1.68 to 1.7 (range of acceptable answer)

**6b.** 0.525 to 0.535 (range of acceptable answer)

**6c.** Linearity,

Normality of residuals,

Independence of Y,

Constant variance,

No outliers

Zero mean of residuals (part of them being normal) (6 marks)

**6d.** SRT increases with body mass (1 mark),

coefficient of 0.53 & R^2 of 0.77 (2 marks if they use one/both of these to say effect is reasonably large).

2 marks if notice that effect is not linear, but decreasing, on original scale

1 mark for uncertainty (standard error = 0.01454), 1 mark for noticing this is < 2 times the estimate so the confidence intervals will not cross zero.

7 marks total

**6e.** 610 to 630 minutes (range of acceptable answer)

**7a.** The normal QQ plot, which checks the normality of the residuals suggests that they do largely follow a normal distribution (1 mark).

There are no signs of outliers, but better to check with cook's distance (1 mark).

No evidence of heteroscedasticity in the residuals vs fitted plot. So this is good (1mark).

There could be evidence of a slight curve though (not linear), there are more points above 0 in the middle of the residuals vs fitted plot than at either end (1 mark).

Total = 4 marks.

**7b.** Curvature was the main problem. The assumption of linearity is not met. This could be improved by adding a quadratic term to the model e.g. log(body mass)2 or use a Box-Cox transformation to decide that level of power is the best.

2 marks for either suggestion. Max = 2 marks

**8a.** Model 2 includes an effect of taxon, i.e. there is a different intercept for each taxon (bird and mammal). Model 1 does not, therefore model 1 assumes that taxon does not affect log(SRT).

2 marks one for each sentence above.

**8b.** Model 3 includes an interaction between body mass and taxon. This gives different slopes for the effect of body mass within each taxon. In contrast model 2 assumes that the effect of body mass is the same in each taxon group i.e. the slope is the same for birds and mammals.

2 marks. One for the interaction and one for how that is different to +.

**9a.** 2 marks for drawing a plot with the correct axes, they must be labelled. (y-axis = log(SRT), x-axis = log(body mass)).

2 marks for drawing two positive slopes i.e. from lower left to top right.

2 marks for mammals have a higher intercept (crosses y-axis at a higher y value) than birds.

2 marks for mammals having a lower slope i.e. less steep, than birds.

**9b.** 480 to 500 minutes (range of acceptable answer)

**10a.** Either model 1 or model 3 are acceptable choices (1 mark, only if justified).

To justify model 3: The ANOVA shows that the data are unlikely to have arisen if either models 1 and 2 were true, i.e. the hypothesis test would reject the null that taxon makes no difference and that there is no interaction between taxon and body mass). We are unlikely to see the F-ratio we estimated for either effect if the null was true. (3 marks)

To justify model 1: Despite the above, the R2shows that model 3 only explains a couple of % more variance than model 1. This shows that the extra complexity, while statistically significant, doesn't make a lot of difference to the model results. (3 marks)

Which you choose depends on the balance between complexity, variance explanation, and reality. It links to differences between a hypothesis test approach or exploratory. Also prediction (when simpler might be better - to predict using fewer variables) versus understanding (when you might want to be more realistic).

**10b**. The predicted SRT for *T.rex*in hours are:

Model 1 = 10 and 1/3 hours

Model 3 = 8 and 1/5 hours

There is a big difference, a *T.rex* could travel far in 2 hours. But the uncertainty in the predictions is large. We cannot really say whether one is closer to the truth than the other. The difference itself is small compared to the uncertainty.

Model 1 predicts two hours longer than model 3.

1 mark for the difference, 2 for the uncertainty comparison (3 total)