(1) What language(s) does this problem involve?

Danish

What is the aim of this problem?

To work out how Danish numbers work.

(2) Background Information

Danish is the language of Denmark, so it is descended from the language of the Vikings and, as a Germanic language, quite closely related to Anglo-Saxon, the ancestor of modern English.

(3) The problem

Here are some examples of Danish numbers:

3 = tre	20 = tyve
4 = fire	30 = tredive
5 = fem	40 = fyrre
6 = seks	57 = syvoghalvtreds
7 = syv	60 = tres
	78 = otteoghalvfjerds
	80 = firs

Tasks

Express the following Danish numbers in figures:

a	treogtyve	
b	seksoghalvtreds	
c	fireogtres	
d	femoghalvfjerds	
e	syvoghalvfems	

What is the Danish for these figures?

f	8	
g	27	
h	36	
i	65	
j	98	

4) Solutions and mark-scheme
One mark per correct answer

a	treogtyve	23
b	seksoghalvtreds	56
c	fireogtres	64
d	femoghalvfjerds	75
e	syvoghalvfems	97

f	8	otte
g	27	syvogtyve
h	36	seksogtredive
i	65	femogtres
j	98	otteoghalvfems

5) Commentary

Commentary: Understanding the system

Look for places where the simple numbers (3-7) are repeated in more complex ones, and mark them with colour; for instance, colour 'tre' green wherever it occurs:

3 = tre
30 = tredive
57 = syvoghalvtreds
60 = tres

Be prepared to overlook some small changes.

4 = fire
40 = fyrre
80 = firs
78 = otteoghalvfjerds

> Look for similarities rather than differences when the differences obscure a clear pattern. After all, our *four* is to *forty* as *five* is to *fifty* in spite of the small changes in spelling and pronunciation.

Now look for patterns among the left-over bits of these complex words. For instance, both *tres* and *firs* seem to contain a suffix -*s*, and there's a -*ds* at the end of 57 and 78. (Again, look for similarities rather than differences.)

60 = tres
80 = firs
57 = syvoghalvtreds
78 = otteoghalvfjerds

> Look for similarities in odd corners of English, or any other language you know.

What do you think this suffix -*s/ds* means? If *tre* means 3, and *tre-s* means 60, -*s* must mean 20. Does that make sense? (Our *score* means 20, and old-fashioned counting gives *four score* = 80.)

-s/ds = x 20

Another partial similarity:

7 = syv
57 = syvoghalvtreds

If *syv* means 7, and *treds* means 3 x 20 = 60, what do you think *oghalv* means? Tricky? Let's put that on hold and see if we're ready to answer any of the questions. And who knows, maybe the data in the questions will help?

> Foreign-language data included in earlier questions may reveal patterns that are not in the initial data!

oghalv = ?

Commentary: Answering the questions

Now try to answer the **first question**: a. treogtyve
What do we know already?

    3 = tre
    20 = tyve

So here we have 3 + *og* + 20. That's useful, because the *og* is part of the mystery pattern *oghalv*, but without the *halv*. But what does *og* mean? One guess is that it means 'and', as in our old-fashioned *three and twenty*. That may be right but we can't be sure.

One thing we can be sure of is that it does **not** mean 'times', because that would give 3 x 20 = 60, and we already know that 60 is *tres*. Another thing is that when *og* combines two numbers, the first is a number from 1-9 and the second is a multiple of 10. Let's call these general word-classes 'units' and 'tens', with the particular meaning U and T; for instance, in our *forty-three*, *forty* is a ten meaning 40 and *three* is a unit meaning 3. Let's record this pattern: **unit U - *og* - ten T = T+U**

So *treogtyve* must be 23.
Now the **next question**: b. seksoghalvtreds
We know:

    6 = seks
    57 = syvoghalvtreds
    7 = syv

So *seksoghalvtreds* must mean 56 - what you get by changing the 7 of 57 into 6. You'll have noticed that we have the mysterious *oghalv* again here, so we can now split it into *og* + *halv*, since the *og* is already accounted for. Moreover, we can also tell that *halvtreds* means 50, because it stands in the tens position after *og*, and the whole thing means 56.   **halvtreds = 50**

Moreover, now we know the basic pattern, we can look back on another number in the initial data:

    78 = otteoghalvfjerds
and be sure that the bit after *og* (*halvfjerds*) means 70.   **halvfjerds = 70**

The **next question** is: c. fireogtres
We know:

    4 = fire
    60 = tres
    Unit U - *og* - ten T = T + U
So we can be sure that *fireogtres* = 64. Nice confirmation of our combination rule.

And the **next question**: d. femoghalvfjerds
We know:

    5 = fem
    78 = otteoghalvfjerds
This is slightly harder than b. (seksoghalvtreds) because we don't know what *otte* means. But we do know that the bit before *og* is a unit, so *otte* must mean 8, and *femoghalvfjerds* must mean 75.   **otte = 8**

The **last Danish-to-English question** is: e. syvoghalvfems
This is the 'crunch' question, which tests your ability to drill down into the inner core of the system.
We know:

    5 = fem
    7 = syv
    Unit U - *og* - ten T = T + U
But: we don't know *halvfems*.

Although we can't look up *halvfems* in the initial data, we can work it out by first working out the underlying principles behind the Danish number system:

- First, because *halvfems* stands after *og*, we can be sure that it is a ten. But we already know 20, 30, 40, 50, 60, 70 and 80. That doesn't leave many options for *halvfems*!
- Second, we know that the suffix *-s* means x 20 (as in *tres* = 3 x 20 = 60). And since we know that *fem* = 5, we can conclude that *fems* means 5 x 20 = 100. But 100, of course, is not a ten! So the crucial question is: what is the effect of putting *halv* before *fems* (or any other number)?
- Third, we know that the tens that start with *halv* are:

  halvtreds = 50
  halvfjerds = 70.

- Moreover, we also know:

  60 = tres
  80 = firs
- And the *treds* and *fjerds* found after *halv-* do look a bit like *tres* and *firs*.
- And, looking at a completely different kind of knowledge, we know that Danish is related to English, so we might guess that *halv* means 'half'.

Putting all those bits of knowledge together, we conclude that *halv* means 'halfway to the next score' - e.g. *halvtreds* means 'halfway from 40 to 60'.
So .... *halvfems* means 90, and *syvoghalvfems* means 97.

halvfems = 90
fems = 100

Now for the **questions asking for Danish forms**. These are straightforward given what we know already.

f. 8 = *otte* (see step 5).
g. 27 = syv*ogtyve*, ('7 and 20'.)
h. 36 = *seksogtredive*
i. 65 = *femogtres*
j. 98 = *otteoghalvfems*

6) Taking it further

Going further: lexical relations

In a dictionary, the words we know are presented as a list (*a, aback, abacus, abandon, ...*) based on the order of letters in the alphabet. But however useful this ordering is - and it really is useful - it can hardly claim to be 'true'. It is only in terms of the alphabet that *aback* is closely related to *abacus* and *abandon*.

If we're aiming at the true structure of English vocabulary, then we need to pay attention to the much deeper and more important relations between words based on their meaning, their grammar and their pronunciation.

For instance, *abandon* is related
- in meaning to *give up*,
- in grammar to all the other verbs, to all the nouns that it tends to combine with, and to the related noun *abandonment*
- in pronunciation to words such as *band, abundant* and others

Once we recognise these much more interesting relations between words, it is easy to see that our vocabulary is not a list at all. Rather, it must be a vast network where a word has many different links to other words. A far cry from the simplicity of a dictionary.

Danish numbers illustrate one particular kind of grammatical relation between words, in which one word appears as part of another. For example, *treogtyve* contains the words *tre* (3), *og* (and) and *tyve* (20). These links connect *treogtyve* to these three words, as well as to the general pattern of units and tens combined by og. If you understand how Danish numbers work, then you know all these linkages. Even in this tiny area of vocabulary it is easy to see how rich the linkages are.

But the relations among words are not only numerous, they are also complicated. For instance, it is common for a word's shape to be slightly altered when it appears in another word. This is one of the challenges of Danish numbers: to recognise the relation between *fire* (4) and *fyrre* (40) you have to ignore the slight difference in shape. The general principle isn't that shape doesn't matter - it does. Rather, the principle is that differences of shape can be compensated for by other linkages. In this case, the rather weak link between *fire* and *fyrre* is counterbalanced by the very strong semantic link between 4 and 40.

The Danish number system is typical, and not that different from English (except for the weird names for 50, 70 and 90). The units reappear in the names of the tens, and (as in English), the higher the number, the more regular its name is.

Suppose English was completely regular, we might expect these number names:

ten, twoten, threeten, fourten, fiveten, sixten, seventen, eightten, nineteen

But we know that the *-ten* is changed to *-ty*, so we actually expect:

ten, twoty, threety, <u>fourty</u>, fivety, <u>sixty</u>, <u>seventy</u>, <u>eightty</u>, <u>ninety</u>

which is exactly what we have, at least in pronunciation if not spelling, for all the underlined words. But the remaining words are incorrigibly irregular - partially as expected, but partially different.

This pattern is typical of 'lexical relations', the relations among words in our vocabulary: partially regular, and partially irregular - but always interesting.